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All communications relating to this Journal should be addressed to the Dean of the Faculty of Science, Imperial University of Tokyo.

The Cambro-Ordovician Shelly Faunas of South America

By

Teiichi KOBAYASHI

With Eight Plates

CONTENTS.

I. Introduction and Acknowledgement

Prior to this research, I had the opportunity of studying the three Cambro-Ordovician faunas of Argentina, namely, the *Kainella* fauna of Prairie Catamarca, the *Parabolinella* fauna of Humahuaca, and the *Leiostegium* fauna of Hambacca. The results of my studies on the first two of these faunas have already been published under the following titles:—

1) On the *Kainella* Fauna of the basal Ordovician Age in Argentina, [Japan. Jour. Geol. Geogr. Vol. XII, (1935), pp. 59—67, 1 pl.]
2) On the *Parabolinella* Fauna from Province Jujuy, Argentina, with a Note on the Olenidae, [Japan. Jour. Geol. Geogr. Vol. XIII, (1936), pp. 85—102, 2 pls.]

A list of the *Leiostegium* fauna of Hambacca is found in the second paper.

As a result of these studies I have come to believe that the faunas of South America consist of Pacific and Atlantic elements with some native features, so that some faunas have been strongly influenced from the Pacific side and others from the Atlantic side. This situation naturally has an extraordinary bearing on the palaeogeographic aspect of the faunas, and I believe that researches into it will lead to the solution of some of the problems concerning intercontinental correlation.

With this idea in mind I endeavoured, during my recent travel in Europe, to look over some of the old collections in the Museums and Institutes, where in many cases I prepared replicas of the types that were exhibited, and where it was possible, borrowed parts of the collections. The original materials which I was able to study are

1) some of KAYSER's types from Argentina kept in the Geological and Palaeontological Institute and Museum, Berlin,
2) LAKE's types from Bolivia kept in the British Museum of Natural History, London,
3) STEINMANN and HOEK's collection, described and undescribed, from Bolivia and Argentina, kept in the Geological Institute, Freiburg i. Br., and
4) BULMAN's type trilobites in the Naturhistoriska Riksmuseum, Stockholm.

Since a thorough study of the Ordovician graptolites of the South American Continent was already made by BULMAN[1] a few years ago, my study here will be confined to the shelly faunas.

This study was begun in 1934. In the mean time, preliminary and summary reports were published on two occassions with titles as follows :—

On the Cambro-Ordovician Faunas of Argentina, Bolivia, and Peru in South America and of the Yukon and Mackenzie Areas in North America, (Preliminary Note), (in Japanese), [Jour. Geol. Soc. Japan, Vol. 42, (1935), pp. 369–371.]

A Brief Summary of the Cambro-Ordovician Shelly Faunas of South America, [Proc. Imp. Acad. Vol. 12, (1936), pp. 296–298, Vol. 13, (1937), pp. 12–15.]

Besides these, *Jujuyaspis steinmanni* KOBAYASHI and *Technophorus otaviensis* KOBAYASHI, both of which are included in the present collections, have already been respectively described in the following two papers as the result of special interest having been aroused in regard to the character of the Proparian and the discovery of ribeirioid on the South American Continent.

1) Proparian Genus of the Olenidae and its Bearing on the Trilobite Classification, [Proc. Imp. Acad. Vol. XII, (1936), pp 176–177, text-figs.]
2) The World-wide Distribution of the Ribeirioid in the Ordovician Period, [Jour. Geol. Soc. Japan, Vol. 43, (1936), pp. 349–358, text-figs.]

I should like in this place to express my sense of indebtedness to Prof. W. SOERGEL of the Geological Institute, University, Freiburg i. Br.; Prof. H. STILLE and Prof. W. JANENSCH of the Geological and Palaeontological Institute and Museum, Berlin; Dr. W. M. LANG and Dr. T. H. WITHERS of the British Museum of Natural History, London; and Dr. S. H. O. STENSIO of the Naturhistoriska Riksmuseum, Stockholm, for the numerous courtesies extended me in the course of my studies in their respective cities.

II. Shelly Faunas of South America

The first investigator to throw some light on the Silurian (s. l.) display in the South American Continent was D'ORBIGNY[2] who discovered *Cruziana rugosa*, *C. furcifera*, *Orthis humboldtii*, *Lingula marginata*, (i. e. *L. submarginata* D'ORBIGNY, 1850,) *L. münsteri*, *L.*

1) O. M. B. BULMAN (1931), South American Graptolites, (Ark. för Zoologi Bd. 22, Nio 3)

2) A. D'ORBIGNY (1842), Voyage dans l'Amérique Méridionale, t. III, Pt. III & & IV, (not seen).

dubia, Graptolites dentatus, Phacops (*Calymene*) *verneuili, B.* (*C.*) *macrophthalma?* and *Asaphus boliviensis* at Tocopaya in the Chaquisaca District. Of these, the two phacopi were believed by SALTER[1] to be Devonian forms, while in BASSLER's Index, *Asaphus boliviensis* was referred to *Megalaspis*, with an interrogation mark.[2]

During his explorations in Peru and Bolivia, FORBES[3] found further evidences of *Cruziana* and its allies in blue micaceous beds in two horizons. This collection was examined by SALTER[4] who described the followings:—

Cruziana cucurbita SALTER (Loc. Valleys of Aceromarka and Unduavi)

Cruziana unduavi SALTER (Loc. ditto.)

Boliviana melocactus SALTER (Loc. Valley of Aceromarka, north-eastern slope of Illimani.)

Boliviana proboscidea SALTER (Loc. ditto.)

Boliviana bipennis SALTER (Loc. Valley of Unduavi, eastern slope of the Andes)

SALTER thought that the fauna belonged to Lower Silurian (i. e. Ordovician) age, because *Bilobites* is much more plentiful below the Caradoc. However, one characteristic species occurs in the Cliniton group of New York.

A fair standard of succession in the Cambro-Ordovician faunas, however, may be attrituted to the efforts of KAYSER,[5] who in 1876, described the Cambrian faunas from Salta and Jujuy and the Ordovician faunas from San Juan and Rioja as follows:—

1) From the sandstone of Salta and Jujuy. a) Tilcuya

Agnostus tilcuyensis KAYSER [*Geragnostus? tilcuyensis* (KAYSER)]

Agnostus sp.

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1) J. W. SALTER (1861), On the Fossils from the High Andes collected by Davis FORBES, (Quart. Jour. Geol. Soc. London, Vol. 17,) p. 72.

2) R. S. BASSLER (1915), Bibliographic Index of American Ordovician and Silurian Fossils, (U. S. Nat. Mus. Bull. 92.)

3) D. FORBES (1861), On the Geology of Bolivia and Southern Peru, (Quart. Jour. Geol. Soc. London Vol. 17), pp. 55–60.

4) SALTER (1861), Op. cit., pp. 62–63, pl. IV–V.

5) E. KAYSER (1867), Ueber Primodiale und untersilurische Fossilien aus der Argentinischen Republik, (Beiträge zur Geologie und Paläontologie der Argentinischen Republik II, Palaeontol. Th. I, Abt. I,) Palaeontogr. Suppl. III.

Olenus argentinus KAYSER	[" *Olenis* " *argentinus* KAYSER]
Arionellus lorentzi KAYSER	[*Plethopeltis lorenzi* (KAYSER)]
Arionellus hieronimi KAYSER	[*Plethopeltis hieronimi* (KAYSER)]
Hyolithus 2 spp.	
Orthis lenticularis WAHL. ?	[? *Orusia lenticularis* (WAHL.)]
Orthis sp.	
(?) *Obolus* sp.	
b) Nevado de Castillo	
Orthis saltensis KAYSER	[*Orusia saltensis* (KAYSER)]
Lingula sp.	
c) Salta	
Orthis saltensis KAYSER	[*Orusia saltensis* (KAYSER)]

2) From the second range of foothills of the Cordillera of San Juan. a) Quebrada de Talacastra

Spongiae indt.	
Monticulipora argentina KAYSER	[*Monriculipora* (?) *argentina* KAYSER]
Lingula sp.	
Orthis calligramma DALMAN	[*Orthis* aff. *calligramma* DALMAN]
Strophomena talacastrensis KAYSER	[*Strophomena* (?) *talacastrensis* KAYSER]
Leptaena sericea SOWERBY	[*Plectambonites* aff. *sericeus* (SOWERBY)]
Ophileta sp.	[*Lesuerilla* sp.]
Murchisonia sp.	
Maclurea avellanedae KAYSER	[*Maclurites avellanedae* (KAYSER)]
Maclurea sarmienti KAYSER	[*Maclurites sarmienti* (KAYSER)]
Maclurea (?) *sterzneri* KAYSER	[*Maclurites sterzneri* (KAYSER)]
Maclurea sp.	
Orthoceras 2 spp.	
Lituites sp.	[? *Lituites* sp.]
Ogygia sp.	
b) Guaco	
Crinoidea indt.	

Ophileta (?) sp.	[*Lesuerilla* (?) sp.]
Orthis obtusa Pander	[*Productorthis kayseri* Kozlowski]
Orthis sp.	
Leptaena stelzneri Kayser	[*Clitambonites* (?) *stelzneri* (Kayser)]
Leperiditia sp.	

c) Quebrada de la Laja

Orthisina adscendens Pander	[? *Vellemo adscendens* (Pander)]
Bathyurus (?) *lajensis* Kayser	[" *Bathyurus* " *lajensis* (Kayser)]
Arethusina argentina Kayser	[" *Aulacopleura* " *argentina* (Kayser)]

d) Quebrada de Juan Podre

Bathyurus (?) *darwini* Kayser	[" *Bathyures* " *darwini* (Kayser)]
Bathyurus (?) *orbignianus* Kayser	[*Bathyurellus* (?) *orbignianus* (Kayser)]

3) From the eastern slope of the Famatina ranges, Potrero de los Anglos, west of Angulos, in Province la Rioja.

Orthis calligramma Dalman var.	[*Plectorthis* aff. *plicatella* (Hall)]
Orthis disparilis Conrad	[*Scenidium* sp.]
Orthis vespertilio Sowerby	[Strophomenoid (?) sp.]
Orthisina adscendens Pander	[? *Vellemo adscendens* (Pander)]
Bellerophon bilobatus Sowerby	[*Sinuites* (?) sp.]
Asaphus sp.	[*Hoekaspis* sp.]
Ogygia cordensis Murchison	[*Hoekaspis* sp.]
Ampyx sp.	

After discussing the generic assemblage and specific alliances, Kayser concluded that the Cambrian fauna is an equivalent of the *Olenus* beds, being related to the Primodial faunas of Northern Europe and Canada; and that the Ordovician faunas may again be most closely related to those of Northern Europe and North America.

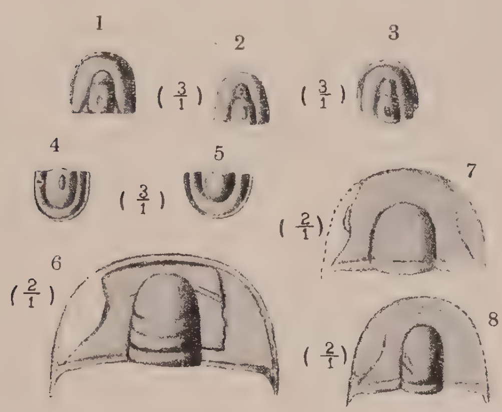
Of the two faunas of Ordovician age, Kayser was of the opinion that the one from San Juan might be older than the one from Rioja.

Brief notes on Kayser's identifications have already been given

in SCHUCHERT's[1] and BASSLER's[2] Indexes, while his identifications of some of the brachiopods have been criticized by WALCOTT[3] and KOZLOWSKI.[4] The bracketted determinations in the foregoing list are based not only on these references, but also on the writer's own studies of published illustrations.

All KAYSER's illustrations are, however, sketches, some of which are not sufficiently clear for accurate comparison, for which reason my comments here are subject to revision, if better material become available.

He compared *Agnostus tilcuyensis* with *A. princeps* SALTER,[5] *A. acadicus* DAWSON,[6] *A. gibbosus* LINNARSSON[7], and other species of the *A. pisiformis* group, of which the second species is considered to be the nearest.



Text-figures 1–4 *Geragnostus* (?) *ticuyensis* (KAYSER)
Text-figures 5 "*Agnostus*" sp.
Text-figures 6 "*Olenus*" *argentinus* KAYSER
Text-figures 7 *Plethopeltis hyeronimi* (KAYSER)
Text-figures 8 *Plethopeltis lorenzi* (KAYSER)
All reproductions from KAYSER's paper (1876)

According to LAKE,[8] *A. princeps* is a compound species composed of *A. trisectus* SALTER and *A. pisiformis*, both belonging to the Longifrontes section of TULLBERG, in addition to *A. rudis* SALTER in the Fallaces subsection of the Limbati section, also

1) CH. SCHUCHERT (1897), A Synopsis of American Fossil Brachiopoda including Bibliography and Synonymy, (Bull. U. S. Geol. Surv. 87.)

2) R. S. BASSLER (1915), Op. cit.

3) C. D. WALCOTT (1912), Cambrian Brachiopoda, (U. S. Geol. Surv. Monogr. 51.)

4) R. KOZLOWSKI (1930), *Andobolus*, gen. nov. et quelques autres Brachiopodes inarticulés de l'Ordovicien de Bolivia, (Bull. du Serv. géol. du Pologne, Vol. VI, Livr. 2.)

5) J. W. SALTER (1866), On the Fossils of North Wales, (Appendix to "the Geology of North Wales" by A. C. RAMSAY), (Mem. Geol. Surv. Great Britain, Vol. III,) p. 296, pl. 4, figs. 2, 11, pl. 5, fig. 5, fig. 1.

6) J. D. DANA (1876), Manual of Geology, 2nd ed. p. 175, figs. 253a–b.

7) S. A. TULLBERG (1886), Om *Agnostus*-arterna i de Kambriska aflageringarne vid Andrarum, (Sver. Geol. Unders. Afh. och Upp. Ser. C, No. 42.)

8) P. LAKE (1906), A Monograph of the British Cambrian Trilobites, Pt. I, (Palaeontogr. Soc.), p. 12.

of TULLBERG. The form that resembles *A. princeps*, according to KAYSER, appears to be the third one. *A. acadicus* (HARTT), according to MATTHEW,[1] belongs in the Fallaces subsection.

A. gibbosus LINNARSSON is, on the other hand, grouped in the Longifrontes section of TULLBERG.

Of the South American agnostids that I have examined, *Geragnostus tullbergi* (nov.) and *G. quadratus* (nov.) most resembled it, although they are probably distinct, seeing that KAYSER's species, besides having no segmentation on the axis of the pygidium (text-fig, 4), appear to have a median tubercle on the posterior lobe of the glabella (text-figs, 1—3).

KAYSER compared *Olenus argentinus* with *O. gibbosus* (WAHL.), *O.* (*Parabolina*) *spinulosus* (WAHL.), *O. cataractes* SALTER and *O. micrurus* SALTER. The last mentioned seems to be the closest to *Olenus argentinus.* As has already been suggested by HOEK,[2] this Argentine species is almost identical with "*Olenus*" *argentinus* of Abra de Escaryache, although its taxonomic position, as will be discussed later, is still in question. Furthermore, this species is similar to *Crepicephalus* (s. l.) or *Kochaspis.*

Arionellus hyeronimi and *A. lorenzi* are certainly allied to *Plethopeltis megalops,* and I believe that they are congeneric. However, the three can be distinguished from one another by the first one having a narrow glabella, and the second a short, smooth glabella and relatively anterior eyes.

Orusia saltensis (KAYSER) at Nevado de Castillo apparently forms a bank with some lingulids, in which respect its mode of occurrence agrees with that of Quebrada de Reyes.

I agree with KAYSER in classifying these faunas of the micaceous sandstones of Salta and Jujuy as Upper Cambrian, but I wonder, if they do not reveal only a single horizon, because, according to STEINMANN and HOEK's collection, the "*Olenus*" *argentinus* sandstone, *Orusia saltensis* sandstone, and the *Plethopeltis megalops* bearing sandstone came from different localities, each with its own lithic aspect and faunal assemblage.

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1) G. F. MATTHEW (1895), Faunas of the *Paradoxides*-Beds in Eastern North America, No. 1, (Trans. N. Y. Acad. Sci. Vol. XV,) p. 212.

2) G. STEINMANN and H. HOEK (1912). Das Silur und Cambrium des Hochlandes von Bolivia und ihre Fauna, (Neues Jahrb. für Min. XXXIV Bd.), p. 209.

The San Juan limestone furnishes the largest faunas including ostracods, trilobites, cephalopods, gastropods, brachiopods, and corals in addition to indeterminable forms of crinoids and sponges. This collection of limestone was made from the four localities of

(1) Quebrada de Talacastra,
(2) Guaco,
(3) Quebrada de la Laja, and
(4) Quebrada de Juan Podre.

Of these, one-half of the San Juan faunas came from the first mentioned locality. These faunas are, as pointed out by KAYSER, quite d stinct from the Bolivian faunas, one reason, for which I presume, is that the former are of calcareous facies while the latter are of arenaceous or argillaceous facies. As the fauna from the first locality is composed of *Monticulipora* (?), *Plectambonites*, *Strophomena* (?), *Maclurites*, *Lesuerilla*, *Orthoceras* and *Lituites* (?), it may properly be placed somewhere in Middle Ordovician. The fauna from the second locality may also be placed near the first.

KOZLOWSKI thought that KAYSER'S *Orthis obtusa* (pl. VIII, figs. 1–2) is a member of the *Orthis obtusa* group or *Productorthis* KOZLOWSKI, but specifically distinct from the European species by its long shell and accentuated ribs, so that a new name, *P. kayseri*, was given to it in 1927.[1]

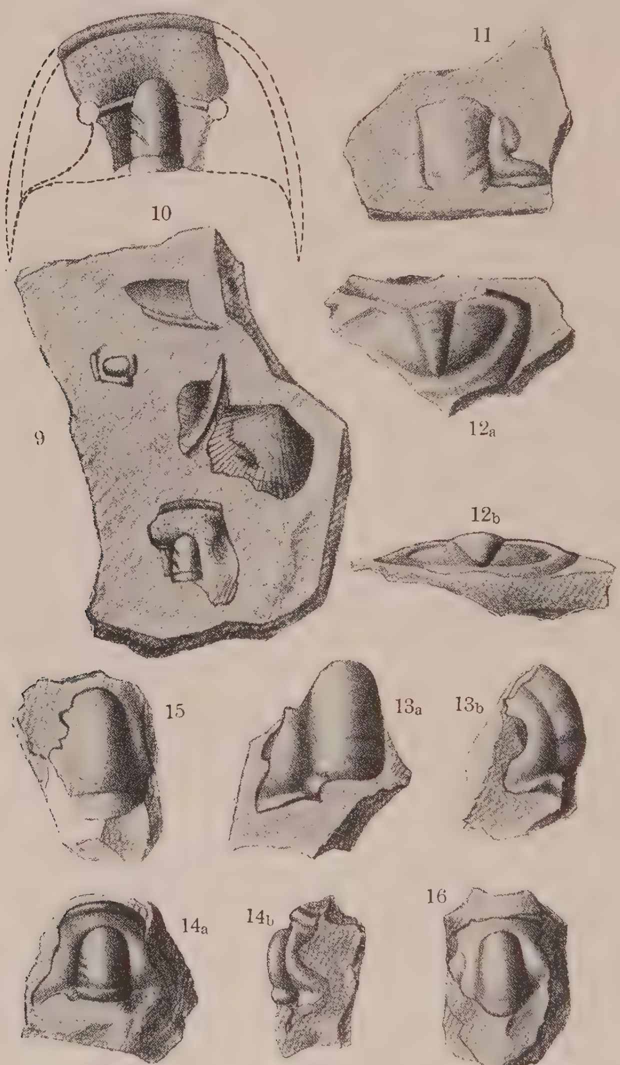
The fauna of Quebrada de la Laja is composed of *Bathyurus* (?) *lajensis*, *Arethusina argentina*, and *Orthisina adscendens*. Since BILLINGS' *Bathyurus*, with which KAYSER compared the first species, was found to be a composite genus, it was split up into several genera in different families by RAYMOND[2] and others. *Bathyurus* s. str. is now restricted to those forms with a long glabellae expanded forward, which characteristic indicates that the Argentine *Bathyurus* should be segregated from *Bathyurus*.

B. (?) *lajensis* appears to me to be quite similar to an underscribed species found in the *Leiostegium* limestone and shale at Cajas, 15 miles west of Hambacca, Argentina. It was listed as Hystricuroid, gen. et sp. nov. in my previous paper. I presume that *B.* (?) *lajensis*

1) R. KOZLOWSKI (1927), Sur certain Orthidés Ordoviciens des Environs de St. Pétersbourg, (Bibliotheca Univ. Liber. Pologne A, Fasc. 17), p. 11.

2) P. E. RAYMOND (1913), A Revision of the Species which have been referred to the genus *Bathyurus*, (Victoria Mem. Mus. Bull. 1,) p. 51.

would be congeneric with, but specifically distinct from, the Cajas species; the similarity probably suggesting that the horizon of the former might be approximately that of the latter in age.



Text-figures 9–10 "*Aulacopleura*" *argentina* (KAYSER)
Text-figures 11–12 *Hoekaspis* sp. (i. e. *Asaphus* sp. and *Ogygia cordensis* Murchison by KAYSER.)
Text-figures 13a–b "*Bathyurus*" *darwini* KAYSER
Text-figures 14a–b "*Bathyurus*" *lajensis* KAYSER
Text-figures 15–16 "*Bathyurellus*" *orbignianus* (KAYSER)
All reproductions from KAYSER' paper (1876)

On the other hand, *Arethusina argentina*, if the generic reference is correct, indicates the Bohemian affinity of the fauna. From the illustration (text-fig. 10) I recognize some resemblance to *Aulacopleura* (i. e. *Arethusina*), although the cephalon and glabella are unusually long, the eye-ridge is oblique, and the carapace appears to have fairly large granules, which makes me think that this might be a true *Aulacopleura*.

The facial sutures are illustrated differently in the text-figs. 9 and 10. In the former the cheek on the right-hand side of the observor has no facial suture anterior to the eye, in which respect, if it is correctly illustrated, this form may be

more or less related to *Entomaspis*.[1]

These trilobites are associated with *Orthisina adscendens* PANDER, which in turn is now referred to *Vellemo* as a genus ranging from Middle to Upper Ordovician, the species occurring in the Echinosphaeritenkalk, which approximates the Chazyan of North America.

It appears to me, however, that this Baltic species may be similar to *O. adscendens* from Potrerodo de los Anglos, but rather distinct from that from Quebrada de la Lajas. KOZLOWSKI has already mentioned that KAYSER's *adscendens* is distinct from PANDER's species.

In view of the strength of "*B*" *lajensis*, I venture to say that the proper age of the Lajas fauna is the Upper Canadian or Chazyan.

The fauna from Quebrada de Juan Podre is represented by two species of trilobites. *Bathyurus* (?) *orbignianus*, with its conical and smooth glabella and divergent facial sutures anterior to the eyes, is rather suggestive of *Bathyurellus*. *Bathyurus* (?) *darwini* might belong to a certain genus of bathyurid, but the specimen is too fragmentary to enable me to say anything definite.

The fauna of Podrero de los Anglos, Famatina, contains eight species of which *Ogygia cordensis* is apparently similar to *Hoekaspis matacensis*. If they are congeneric, the pygidium of the former would be that illustrated in text-figs. 12a–b.

KAYSER's *Bellerophon bilobatus* is at any rate specifically distinct from *Sinuites bilobatus* (SOWERBY), since his species is much more compressed laterally.

KOZLOWSKI has pointed out that *Orthis calligramma* from Quebrada de Talacastra resembles *O. calligramma* itself, but this species from Podrero de los Anglos approaches *Plectorthis* owing to the great convexity of the dorsal valve. The view that KAYSER's species appears to be more closely related to *O. plicatella* (HALL) has already been expressed by SCHUCHERT.

SCHUCHERT, moreover, suggested that *Orthis disparilis* is probably a new species, while KOZLOWSKI thought that the species belongs to *Scenidium*. The latter thinks that *Orthis verspertilio* belongs to the Strophomenacea.

Without seeing the original material it is almost impossible to

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1) E. O. ULRICH (1930), in J. BRIDGE's Geology of the Eminence and Caradreva Quadrangles, (Miss. Bur. Geol. Mine. Vol. XXIV, Sec. Ser.), p. 212.

discuss further, particurarly in the case of the brachiopods. It may, however, be suggested that the fauna from Potrero de los Anglos might be similar to the *Hoekaspis* red sandstone of Mataca, so far as concerns the possible inclusion of *Hoekaspis* in Podrero de los Anglos.

In his next paper,[1] in 1897, KAYSER gave the following list :—

1) Middle Cambrian fauna from Province Salta in northern Argentina ; in a hard, finegrained, light gray, quartzose sandstone.

Fossil \ Locality	Iruya	Ojo de Agua
Liostracus steinmanni KAYSER	×	
Liostracus ulrichi KAYSER	×	
Agnostus iruyensis KAYSER	×	
Orthis saltensis KAYSER ?		×
Lingulella cfr. *ferruginae* SALTER	×	
Lingulella cfr. *davisii* SALTER	?	?

2) Lower Silurian Fauna of Argentina.

1. Fossils from a hard, yellowish sandstone of north Argentina.

Fossil \ Locality	Portezuelo	Mudana
Megalaspis sp.		×
Bellerophon sp. (*Clymbularia* aff. *cultrijugata* ROEMER)		×
Didymograptus sp.	×	

Scolithus-like fossils are found in a slab of light purplish red, fine grained quartzose sandstone of Mudana.

2. Fossils from a thick series of limestone and dolomite of Cerro del Fueroo, east of Jachal, San Juan Prov., Argentina.
Illaenus argentinus KAYSER
Maclurea avellanedae KAYSER
Leptaena sericea SOWERBY
Orthis calligramma DALMAN ?

1) E. KAYSER (1897), Beiträge zur Kenntniss einiger palaeozoischen Faunen Süd-Amerikas, (Zeitsch. deutsch. geol. Gesell. XLIX), pp. 274–317, pl. VII.

KAYSER discriminated two species of *Liostracus*, *ulrichi* and *steinmanni*, by the convexity of their cranidia, outline of their glabellae, strength of their glabellar furrows, breadth of their preglabellar fields, and so forth. The former is represented by the cranidium only; the latter by the cranidium, free cheek, and pygidium. He compared the two with *Liostracus linnarssoni* BRÖGGER,[1] *Ptychoparia quadrata* (HARTT), *Liostracus ouangoniana* (HARTT), and *L. ouangoniana* var. *aurora* HARTT.[2] *Agnostus iruyensis* is compared with *A. nudus* BEYR., and is referred to the Laevigati section of TULLBERG.

From the presence of *Liostracus* and *Agnostus iruyensis*, KAYSER concluded that the *Liostracus* fauna should be compared with the Paradoxidian, or the Middle Cambrian of the Atlantic province.

Liostracus ulrichi, with respect to the cranidium, it is scarcely distinguishable, generically, from *Andesaspis catamarcensis*, which in turn, however, is quite distinct from all of *Liostracus*, especially in the pygidium. *Liostracus steinmanni* is not unlike *Loganellus logani* (DEVINE),[3] except that the anterior facial sutures, which are distinctly divergent in the latter, are parallel or rather convergent in the former.

HOWELL[4] referred *Agnostus iruyensis* to his *Gallagnostus*. To me, *A. iruyensis* appears to be a *Phalacroma*.

Orthis saltensis (?) is a species that was first described from the *Olenus* bed of Argentina and referred later by WALCOTT[5] to *Orusia*. The identification of KAYSER's *L.* cfr. *ferruginea* with SALTER's species, is accepted in WALCOTT's monograph on Cambrian brachiopods, but KAYSER's *L.* cfr. *davisii* is suggested as being possibly a new form or one identical with a certain form of the species in New Brunswick or Newfoundland. The two species of atremate brachiopods are considered by WALCOTT to be Upper Cambrian, although *L. ferruginea* is known to occur also in the Middle Cambrian.

Not having been able to see the original material, I cannot discuss further, but the foregoing information will, I think, suffice to point out that an ambiguity exists as to whether the so-called

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1) G. LINNARSSON (1882), De under *Paradoxides*-lagren vid Andrarum, (Sevr. Geol. Lunderskr. Afhandl. No. 54), pl. 4, figs. 5–11.

2) C. D. WALCOTT (1884), On the Cambrian Faunas of North America, (Bull. U. S. Geol. Surv. No. 10), pp. 37–39, pl. 5, figs. 1, 4–5.

3) E. BILLINGS (1865), Palaeozoic Fossils, (Geol. Surv. Canada), p. 201, figs. 185–186.

4) B. F. HOWELL (1935), Cambrian and Ordovician Trilobites from Hérault, Southern France, (Jour. Pal. Vol. 9, No. 3), p. 227.

5) WALCOTT (1912), Op. cit., pp. 290, 299.

Liostracus zone is really Middle Cambrian or later.

As to the Ordovician faunas, KAYSER stressed the occurrence of *Didymograptus* sp. He compared *Megalaspis* sp. with *M. planilimbata;* *Bellerophon* sp. with *B. cultrijugatus;* and *Didymograptus* sp., together with D'ORBIGNY'S *Graptolithus dentatus* from Tacopaya, Bolivia, with *D. murchisoni*. Judging from the *Megalaspis* and *Bellerophon*, he assigned the Mudana fauna to the Orthocerenkalk of the Baltic region.

ROEMER'S species were later transferred from *Bellerophon* s. str. to *Cymbularia* by KOKEN and PERNER[1]; and BULMAN[2] commented that KAYSER'S *Didymograptus* sp. should probably be referred to *D. nitidus*, indicating an Arenig age, and that it is in reality quite distinct from D'ORBIGNY'S form.

In the Mudana collection in Berlin I found the cranidium and free cheek associated with *Megalaspis* sp. As will be seen from the result of my study given in the description, this is certainly not a *Megalaspis* s. str., so that a new genus, *Megalaspidella* was founded on *Megalaspis* sp. by KAYSER, i. e. *Megalaspidella kayseri*, a new species. This species resembles *Homotelus indentus* RAYMOND from the Holsten in Virginia. In the same collection I found an undescribed Bellerophontacea which is fairly close to *B. similis* ULRICH and SCOFIELD, except for the surface ornament; and which is called *Bucania mudanensis* (nov.)

As to the chronology of the Ordovician faunas, the species gave but little information, excepting a graptolite, on the strength of which BULMAN suggested Arenigian as the age of the fauna.

KAYSER[3] described in his third paper, four additional species from a light yellow or greenish gray and arenaceous (or argillaceous) sandstone of Salta, Argentina, as follows:—

Thysanopyge argentina KAYSER
Megalaspis sp.
Megalaspis brackebuschi KAYSER
Pterigometopus saltensis KAYSER

The first species (Pl. III, fig. 20) was formerly identified with

1) E. KOKEN and J. PERNER (1925), Die Gastropoden des baltischen Untersilurs, (Mém. de l'Akad. des Sci. de Russie VIIIe Ser. Vol. XXXVII, No. 1), p. 3.
2) BULMAN (1931), Op. cit., p. 3.
3) E. KAYSER (1898), Weitere Beitrag zur Kenntniss der ältern palaeozoischen Faunen Süd-Amerikas, (Zeitsch. deutsch. geol. Gesell. Bd. 50), pp. 423–429, pl. XVI.

Dalmania caudata by FRECH,[1] who concluded from the fact that the trilobite is found associated with *Pristograptus*, that the fauna indicated the presence of Upper Silurian; or Gotlandian, in South America.

Through restudy of the material, however, KAYSER maintained, in contradiction to FRECH, that FRECH's *D. caudata* has nothing to do with SALTER's species, but that it belongs to the *Megalaspis* group, although it is distinguished from *Megalaspis* s. str. by the indentation of the posterior margin and telson. Moreover, he added that FRECH's *Pristograptus* is a strip of *Didymograptus*. The two are thus regarded as revealing not the Gotlandian, but the Ordovician age. Seeing that the genus, *Megalaspis*, was at that time confined to Europe, this fauna may be correlated to the Vaginatenkalk of the Baltic province.

The outstanding characteristics of *Megalaspis* sp. (cranidium, pl. III, fig. 19) are its subsquare glabella, relatively anterior eye, disconnected occipital furrow, isoteliform (?) facial suture, etc. As none of the megalaspids have such a combination of characteristics, this presumably is a cranidium of *Thysanopyge*.

Not only the first species, but also the third and fourth show certain similarities with the pygidium of *Megalaspis* in a broad sense. To me it appears hardly possible to overlook the close resemblance of *Megalaspis brackebuschi* (pl. III, fig. 19,) to *Xenostegium douglasensis* WALCOTT[2] and *X.* (?) *paradouglasensis* KOBAYASHI,[3] as also that of *Pterygometopus saltensis* (pl. III, fig. 2) to *X. euclidus* WALCOTT.

WALCOTT's *Xenostegium* itself, is a waste-basket containing *Megalaspis*-like asaphids with a triangular pygidium having a defined border and caudal telson. However, considerable variation is seen in the cranidia of the species referred to the genus. *M. belemnurus*, the genotype, is however, fairly well characterised by the aspect of the axial lobe of the pygidium. *Megalaspis* of the Baltic region itself is also a comprehensive genus involving very wide variations.

If the entire group of megalaspids,-*Megalaspis*, *Megalaspides*, *Xenostegium*, and *Thysanopyge* were to be re-classified, *Xenostegium douglasensis* and its relatives might be placed outside of *Xenostegium* s. str. It is, however, quite certain that the *douglasensis* group is the cha-

1) F. FRECH (1880–97), Lethaea Palaeozoica, Bd. 1, p. 679.

2) C. D. WALCOTT (1925), Cambrian and Ozarkian Trilobites, (Smiths. Misc. Coll. Vol. 75, No. 3), p. 125, pl. 24, figs. 22–23.

3) T. KOBAYASHI (1934), Cambro-Ordovician Formations and Faunas of South Chosen, Palaeontology, Pt. II, (Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. II, Vol. III, Pt. 9), p. 559.

racteristic of the megalaspid in the Pacific province, so that the close affinity of the Salta fauna with the Baltic fauna, as emphasized by KAYSER, is not definite.

Incidentally, there arises a fundamental question with regard to the so-called *Megalaspis limbata* fauna, which is found in the Sarbach formation of western Canada.[1] I once looked over the collection of this fauna in the U. S. National Museum and could hardly deny its close morphological similarity with the *M. limbata* fauna of the Baltic region. Furthermore, even *Megalaspis brackebuschi* is, as has already been suggested by KAYSER, not quite unlike *Megalaspis heros.*

Whether this resemblance between the eastern Pacific and Scandinavian faunas is homologous or analogous is not yet decided, but, should the former be the case, how are we to explain the total abscence of *Megalaspis* fauna in such a wide area including the greater part of North America? We shall revert to this question later.

Returning to Bolivia, ULRICH,[2] in 1893, described the following species from three localities:—

1) *Lingula*-Schiefer von Pocona (zwischen Vacas und Totora auf der Route Cochabamba-Sta. Cruz de la Sierra)
   ? *Siphonotreta* sp.
   Lingula münsteri D'ORBIGNY
   Lingula attenuata SOWERBY
   Cruziana furcifera D'ORBIGNY
2) *Lingula*-Schiefer zwischen Sucre und Yamparaez.
   Lingula sp.
   Lingula sp.
   Cruziana furcifera D'ORBIGNY
3) Thon-Schiefer oberhalb Parautani (Alter umbestimmt. Silur? Devon?)
   Lingula sp.

He thought the first, and probably the second also, were Ordovician.

Subsequently, in 1906, LAKE[3] distinguished the following species

1) C. D. WALCOTT (1928), Pre-Devonian Palaeozoic Formations of the Cordilleran Province of Canada, (Smiths. Misc. Coll. Vol. 75, No. 5), p. 222.

2) A. ULRICH (1893), Palaeozoische Versteinerungen aus Bolivien, in STEINMANN's Beiträge zur Geologie und Palaeontologie von Südamerika, (Neues Jahrb. f. Min. VIII Beil.-Bd.), pp. 6–9, 87–90, pl. I & V.

3) P. LAKE (1906), Trilobites from Bolivia, collected by Dr. J. W. EVANS in 1901–1902, (Quart. Jour. Geol. Soc. London Vol. LXII), pp. 425–430, pl. XL.

in EVAN's collections[1]:—

1) *Peltura* sp. from a soft, pale-violet or purple shale at Cochaiya, about 3 miles northeast of Pata on the route from Apolo to Pelechunco, via Pata, province of Caupolican. He correlated this shale with the Dolgelley beds or Upper *Lingula* Flag.
2) *Symphysurus apolinista* LAKE and *Trinucleus boliviensis* LAKE from a large block of sandstone about a mile from Apolo, province of Caupolican, in a direction slightly northwest. He considered the sandstone to be Arenigian, seeing that *Symphysurus* is restricted to the Tremadoc and Arenig, and since *T. boliviensis* resembles *T. coscinorrhinus*.
3) *Ogygia* sp. from the right bank of the River Caca, between the mouth of the River Challana and that of the Coroico, Province of Caupolican.

According to him this indicates the Ordovician age probably at its lower part. In 1934, I had the oppotunity of studying the original material at the British Museum of Natural History. Since *Peltura* sp. has no glabella, we cannot go further than LAKE has done. It may, however, quite possibly be *Peltura*. At least it is certain that it belongs to the Olenidae. Accordingly, this indicates that the Upper Cambrian fauna of Bolivia is of the Atlantic type.

Most of the characteristics of *Trinucleus boliviensis* are diagnostic of the *T. foveolatus–T. coscinorrhinus* group. STETSON,[2] moreover, left the species in *Trinucleus* s. str. *Symphysurus apolinista* is, on the other hand, quite distinct from *Symphysurus*. A precise description will be found on a later page. Since in my opinion it is a new genus, *Lakaspis* has been established from it.

The hypostoma and pygidium of *Ogygia* illustrated by LAKE apparently do not come from one horizon, since the former is in a black shale and the latter in a hard sandstone in association with the hypostoma of another type. As will be discussed latter, LAKE's hypostoma may belong to *Niobella* and the pygidium to *Ogyginus*.

Due to STEINMANN and HOEK's excellent researches,[3] a comprehensive geologic sequence provided with fossil zones has since been

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1) J. W. EVANS (1903), Expedition to Caupolican, Bolivia, (Geogr. Jour. Vol. 22.)
2) H. C. STETSON (1927), The Distribution and Relationships of the Trinucleidae, (Bull. Mus. Comp. Zool. Vol. LXVII, No. 2,) p. 99.
3) G. STEINMANN and H. HOEK (1912), Op. cit.

brought to light from the Bolivian Highland. The Cambrian strata are, except for the *Peltura* shale in Caupolican province, restricted to the southeastern corner. The fossiliferous micaceous sandstone was found at Cerra de Yuchara and Cerro Campanario, where sandstone overlies the grayish blue or reddish gray quartzite. The fossils in it are

1) *Arionellus* sp. collected at a point between Patancas and Vicunaga, western slope of Cerro Campanario.
2) *Olenus* cfr. *argentinus* Kayser, on the western slope of Escayache Pass, about half an hour's walk from the top, 3600 m. above sealevel, and
3) *Conocephalites* cfr. *striatus* Emmrich, *Liostracus* sp., *Arionellus* cfr. *hieronymi* Kayser and *Orthis* sp. in the valley due south of Tambo Guanacuno and west of Escayache.

The fossilliferous sandstone may be a northern extention of *Olenus argentinus*-bearing sandstone in adjacent Argentina.

At Salitre, on the Bolivia-Argentina Boundary, there has been discovered *Agnostus bolivianus* Hoek and *Parabolinella andina* Hoek in black shale; the faunule indicating a new horizon of latest Cambrian or earliest Ordovician. Besides these, *Lingulella* cfr. *davisii* Salter was found in a similar shale one km. north of that locality.

The Cambrian section developed there may, therefore, be summarized in descending order as follows:—

3) *Parabolinella andina*-bearing black shale.
2) *Olenus* cfr. *argentinus* and *Conocephalites* cfr. *striatus*-bearing sandstones.
1) Gray non-fossiliferous quartzite,

Although the stratigraphical relation between the second and third beds was not actually determined, superposition may be surmised from the palaeontological evidences. Moreover, since in the section near Tarija the basal Ordovician sandstone lies over the Cambrian sandstone and quartzite, this transitional black shale at Salitre may be a merely local manifestation.

It is also noteworthy that so far as I can see in the collection, three fossil zones may be distinguished in the second bed, the one a white micaceous coarse grained sandstone containing *Olenus argentinus,* and the other a brown micaceous fine grained sandstone containing *Conocephalites* cfr. *striatus,* and still another, a white medium grained sandstone containing *Conocephalites* cfr. *striatus.*

I do not know, however, whether these indicate different facies

in the same horizon or really different horizons, because the lithic aspects and the contained fossils are rather distinct, although there are common species, for example, *Conocephalites* cfr. *striatus* (partim) i. e. *Plethopeltis megalops*, being found in the three and *Geragnostus tullbergi* in the last two horizons.

The Ordovician formation is extensively displayed in the highland, but the younger formations on the western side of a line drawn from Cochabamba to Camargo through Tarabuco, south Sucre, are contorted. On the eastern side of the line, where, on the other hand, the strata are not so disturbed, good Ordovician sequences are seen.

The following eight sections are from the highland by STEINMANN:—

1) Tarija-Rio S. Juan
2) Tambillos-Ollacasa
3) Tarabuco-Yamparez
4) Sucre-Cochabamba
5) The Tunari mountains
6) Cuesta de Tapacari
7) Profil at Capinota
8) Profile between Caraz and Cochabamba

In the first area appear two valuable successions of the Lower and Middle Ordovician. The one at Cuesta de Erquis contains three important fossil beds, namely, the lower or *Kainella* yellowish shale, the middle or *Dictyonema* light gray or black shale, and the upper or *Parabolinopsis* white shale, in addition to a brachiopod-bearing gray shale inserted between the lower and middle shales. The *Kainella* shale lies over the Cambrian sandstone and quartzite.

In another area near Tarija the Lower Ordovician formation has again three fossil beds, namely, the lower or asaphid sandstone, middle or *Dictyonema* and *Didymograptus* black shales, and the upper or cephalopod shale with " Nagelkalk ". This upper shale is called the geode-shale.

In the second and third routes the lingulid shale or sandstone lies on the *Cruziana* quartzite-bearing sandstone, the *Lingula* shale on the *Bilobites* sandstone in the fifth route.

In the fourth route the *Lingula* shale and sandstone containing *Homalonotus bistrami*, *Arca gracilis*, and other fossils are located between the *Cruziana* sandstone and *Scolithus* quartzite, while in the

eighth profile the *Lingula* shale is covered by the *Scolithus* quartzite, which in turn yields *Nucula* sp., namely, *Ctenodonta cochabambensis* described here.

In the seventh profile is found a *Trinucleus* bed in platy shales; the contained fauna is rich, comprising *Trinucleus krugeri, Calymene diademata, Megalaspis americana,* and others. On the slope of Huacaplaza, the shale is covered by the *Lingula* sandstone.

The Ordovician sections referred to above were compiled by STEINMANN as follows:—

Lower Devonian sandstone.

—Weak discordance—

7) Upper Ordovician quartzite with *Scolithus* and *Nucula.*

6) *Lingula* sandstone at least 100 m. thick containing,
Lingula münsteri D'ORBIGNY,
L. lineata HOEK,
L. inornata HOEK,
Tunaria cochabambina HOEK,
Pizarroa quichuana HOEK,
Bistramia elegans HOEK,
Arca gracilis HOEK,
Homalonotus bis'rami HOEK, and so forth.

5) *Bilobites* sandstone with *Cruziana* (*Bilobites*) *furcifera* D'ORBIGNY about 500 m. thick.

4) Geode-slate containing,
Orthoceras bolivianum HOEK,
Endoceras sp.,
Ogygia liquensis HOEK,
Trinucleus krugeri HOEK,
Calymene diademata (?) BARRANDE,
Megalaspis americana HOEK, and
Chasmops cfr. *bussulenta* SJÖGREN,

3) Middle quartzite 200-300 m.

2) Graptolite slates.

b) Black slate containing *Didymograptus nitidus* HALL and *Lingula* cfr. *attenuata* SOWERBY.

a) Black slate containing *Asaphus nobilis* Barrande, *Cheirurus* sp., *Pliomera* (?) sp., *Dictyonema murrayi* HALL var. *tarijense* HOEK and (?) *Tetragraptus* cfr. *headi* HALL.

Since they could not be found in one section, it is not certain whether the two slates, a and b, indicating different horizons, or belong to the same niveau.

I) Lower quartzite and slate.

Furthermore, gray, yellowish or reddish sandstone and quartzite are interbedded with the sandy shales and are 300 to 400 m. thick. The contained faunas are *Megalaspis americana* HOEK, *M.* cfr. *planilimbata* ANGELIN, *M. matacensis* HOEK, *Orthis saltensis* KAYSER, *O.* cfr. *carausii* SALTER and *Scolithus*; *Parabolina andina* HOEK, *Agnostus boliviensis* HOEK and *Lingulella davisii* SALTER (Upper Cambrian ?); and *Asaphus* cfr. *tyrannus* MURCHISON and *A.* cfr. *powisii* MURCHISON (Upper Ordovician ?) The number of faunas included in this group indicated that the beds should be split up into a number of horizons.

A palaeontological study undertaken by HOEK[1] has resulted in the determination of a number of species from various localities as follows:—

A. Cambrian.

1. Cuesta de Escayache between Tarija and Rio San Juan.
   Olenus cfr. *argentinus* KAYSER [*"Olenus" argentinus* KAYSER]
2. Pampa de Tacsara between Tojo and Tarija.
   Arionellus sp. [*Plethopeltis megalops* KOBAYASHI]
3. Tambo Guanacuno on the Cuesta de Escayache between Tarija and Rio San Juan.
   Liosrtacus sp.
   Arionellus sp. [*Plethopeltis megalops* KOBAYASHI]
   Conocephalites cfr. *striatus* EMM. { *Plethopeltis megalops* KOBAYASHI, *Jujuyaspis steinmanni* KOBAYASHI, *"Ptychoparia"* sp. }

In addition to these three, a slab of sandstone from Abra de Chorcoya belongs to the Upper Cambrian. The faunas are tabulated as follows:—

1) STEINMANN and HOEK (1912), Op. cit.

Fossil \ Locality	Cuesta de Escayache	Pampa de Tacsara	Abra de Chorcoya	Tambo Guanacuno
Orthid, a sp. (Pl. VII, figs. 1-2)	×			
Orthid, b. sp. (Pl. VII, figs. 6)				×
Pelagiella escayachensis	×			
Phalacroma atuberculata	(×)			×
Geragnostus tullbergi			×	×
Plethopeltis megalops	×	×	×	×
" *Olenus* " *argentinus*	×			
Jujuyaspis steinmanni				×
" *Ptychoparia* " sp.				×
Angelina (?) gen. et. sp. indt.				×
Hypostoma gen. et. sp. indt.		×		

The *argentinus* sandstone of Escayache can be correlated with that of Tilcuya not only because of the common occurrence of this species, but also because of the extraordinary resemblance between *Geragnostus tullbergi* and *Agnostus tilcuyensis*, and between *Plethopeltis megalops* and *Plethopeltis hyeronimi*. Since *Plethopeltis megalops* occurs in all localities, the other three may be near this horizon. The true taxonomic position of " *Olenus* " *argentinus* is now inderminable, but *Plethopeltis* shows an alliance of the faunas to the late Upper Cambrian of North America, and if " *Olenus* " *argentinus* is a crepicephalid, the affinity is still more marked, while at the same time the "*argentinus*" sandstone may be older than others. At any rate, the faunas as a whole are certainly in the Upper Cambrian, instead of in the Middle Cambrian as pointed out by Hoek.

Since, as discussed elsewhere, *Jujuyaspis* is a derivative of the Olenidae and occurs also at Humahuaca in a black shale where it is associated with *Parabolinella argentinensis*, a certain degree of Atlantic alliances would be expected. In its lithic aspects, the black shale of Humahuaca resembles the shale of Salitre to be mentioned later, but it is slightly more coarsegrained and apparently more carbonaceous.

B. Upper Cambrian or Lowest Ordovician.

Salitre.

Agnostus bolivianus Hoek. [*Gallagnostus bolivianus* (Hoek)]
Parabolinella andina Hoek. [*Parabolina andina* (Hoek)]

Lingulella davisii SALTER

In the Salitre fauna I distinguished

Gallagnostus bolivianus (HOEK),

Olenus (?) sp., and

Parabolina andina (HOEK).

Parabolina as a genus ranges in Sweden from the *Parabolina spinulosa* zone to the zone with *Acerocare, Cyclognathus* and *Parabolina,* and is distributed also in Norway, Poland, England, New Brunswick, and Nova Scotia. However, since all the species so far known are confined to late Upper Cambrian, this Salitre shale should be regarded as late Upper Cambrian rather than Tremadocian.

C. Ordovician.

1. Aguas Calientes (Quebrada de Reyes,) West Jujuy.

Orthis saltensis KAYSER [? *Orusia saltensis* (KAYSER)]

Megalaspis cfr. *planilimbata* ANGELIN

2. Agnostura de Queta, between Cochinoca and Rinconada in North Argentina.

Didymograptus nitidus HALL

3. Abra de Chorcoya.

Megalaspis americana HOEK

4. Escayache Range.

Orthis carausii SALTER [*Finkelnburgia samensis* KOBAYASHI]

5. Cuesta de Erquis.

Asaphus cfr. *nobilis* BARRANDE

Cheirurus sp. [*Kainella billingsi* (WALCOTT)]

Pliomera sp. [*Protopliomerops punctulifera* KOBAYASHI]

Dictyonema murrayi HALL, var. *tarijense* HOEK=*Dictyonema retiformis* (HALL) COURTY

Dictyonema irregulare HALL

Tetragraptus headi HALL (?)=*Dendrograptus hallianus* (PROUT) COURTY

The most interesting is a wonderful display of *Kainella* in the boundary areas between Bolivia and Argentina. The occurrence of this genus on the continent was first made known from Prairie Catamarca. In the course of this revision I found the genus contained in STEINMANN and HOEK's collections from various localities.

Megalaspis americana by Hoek is, in fcat, a composite species including *Asaphellus* (*Asaphelloides*) *americanus* and *Kainella meridionalis*.

The *Kainella* fauna is found in two kinds of rocks, yellowish or dark gray micaceous shale and hard, gray or light yellow sandstone, that is, in sandstones at Abra de Chorcoya and Aguas Calientes (Abra de Chorcoya in Hoek's list), in shales at Cuesta de Erquis, Cuesta de Calama and west of Obispo, and in sandstones as well as in shales at Guanacuno. The fauna of various localities is shown in the following table.

Locality (Rock) / Fossil	Cuesta de Erquis (shale)	Cuesta de Calama (shale)	East of Obispo (shale)	Guanacuno (shale)	Guanacuno (sandstone)	Aguas Calientes (sandstone)	Cuesta de Sama (sandstone)	Cuesta de Sama (shale)	Abra de Chorcoya (quartzite)
Cystoid, gen. et sp. indt.	×		×					×	
Lingulid, gen. et. sp. indt.	×	×							
Acrotreta cfr. *curvata* Walcott	×								
Orusia putilliformis (Kobayashi)						×			
Finkelnburgia samensis Kobayashi							×	×	
Gastropod, gen. et. sp. indt								×	
Pseudagnostus (*Rhaptagnostus*?) *semiovalis* Kobayashi			×						
Geragnostus quardratus (Kobayashi)	×		×	×					
Kainella billingsi (Walcott)	×								
Kainella meridionalis Kobayashi	×	×		×		×		?	
Protopliomerops punctulifera Kobayashi	×	?							
Plethopeltis megalops Kobayashi				×					
Plethometops microphthalmus Kobayashi					×				
Parabollina sp. indt.			×						
Angelina punctolineata Kobayashi	×								
Shumardia erquensis Kobayashi	×			×					
Asaphellus (*Asaphelloides*) *americanus* (Hoek)	×	?	×	×	×	×			×

Kainella is of course a characteristic of the basal Ordovician, or or late Ozarkian of ULRICH, being dominant in the southeastern Pacific province. *Angelina* and *Parabolina* (?), on the other hand, shew certain faunal affinities with the Atlantic species. *Andesaspis*, found in the *Kainella* sandstone of Prairie Catamarca, is an endemic genus in this region, and *Plethopeltis megalops* only a survivor of the Upper Cambrian fauna.

Dictyonema is found not only in the shale superjacent to the *Kainella* bed, but in the *Kainella* shale. I have seen the graptolites in a hand specimen of *Kainella* shale in the collection. *Didymograptus nitidus* indicates the Arenig and *Didymograptus* shale is higher than the asaphid sandstone (or *Kainella* zone) in the Tarija section. These evidences force me to regard the *Kainella* zone as in the Tremadoc. The Lower Ordovician fossil zones in the region may tentatively be summarized as follows:—

Arenigian	*Didymograptus nitidus* shale
Tremadocian	*Dictyonema* shale *Kainella* sandstone and shale

Although the sandstones from Cuesta de Sama and Cuesta de Escayache contain only *Finkelnburgia samensis*, in the *samensis* shale from the former locality we find *Kainella*, besides inderterminable fragments of gastropods and cystoids, so that the *samensis* shale and sandstone may belong somewhere in the *Kainella* bed.

A sandstone from Aguas Calientes is full of *Orusia saltensis*, in addition to a few lingulids. Its position shows that this sandstone may safely be correlated with the *saltensis* sandstone of Salta and Nevada de Castillo. This sandstone is considered by HOEK to be in the Lower Ordovician, while KAYSER places it in the Upper Cambrian. *Orusia*, as a genus, ranges from Upper Cambrian to Canadian, although the specific resemblance between *saltensis* and *lenticularis* might place it in Upper Cambrian.

A sandstone boulder collected from the Rio Grande near Ciudod, Jujuy, contains *Riograndella subcircus*, but nothing else. The genus being new, its age cannot be accurately determined.

6. Cuesta de Escayache near San Lorenz.

This white shale contains *Parabolinella* aff *shinetonenesis* besides *Parabolinopsis mariana*. The former species suggests the Tremadoc age of the shale, but the exact horizon with reference to the preceding zoning is unknown.

7. Quechisla, west Cotagaita.
   Orthoceras bolivianum HOEK [*Ormoceras bolivianum* (HOEK)]
8. Tambo Sivingomayo.
   Ogygia liquensis HOEK [*Pseudobasilicus liquensis* (HOEK)]
9. San Lucas, North Camargo.
   Endoceras sp. (" *Endoceras* " spp.)
10. Otavi, Southeast Potosi.
    Diplograptus whitefieldi HALL
11. Pampa de Otavi between San Bartolo and Mataca.
    Megalaspis matacensis HOEK [*Hoekaspis matacensis* (HOEK)]
12. Escalera pass between Mataca and Tambillos.
    Asaphus cfr. *tyrannus* MURCHISON [*Basilicus* aff. *tyrannus* (MURCHISON)]
    Asaphus powisii MURCHISON [*Parabasilicus* aff. *typicalis* KOBAYASHI]
13. Sucre, a few miles east of the town.
    Endoceras sp. [" *Endoceras* " sp.]
    Megalaspis matacensis HOEK?
14. Cerro Pocotaica near Capinota (South Cochabamba.)
    Trinucleus krugeri HOEK
    Calymene diademata BARRANDE [*Calymene* (*Synhomalonotus* ?) *pompeckji* KOBAYASHI]
    Chasmops cfr. *bucculenta* SJÖGREN
    Asaphus (?) sp.
    Orthothetes sp.
    Bellerophon (?) sp.

Accordiug to STEINMANN, the section of Capinota is composed of black platy shales 130 m. thick, while within a distance of one-third the height of the mountain from the top are found

Orthis boliviensis KOBAYASHI,
Trinucleus krugeri HOEK, and
Calymene (*Synhomalonotus*?) *pompeckji* KOBAYASHI.

This locality is called Cerro Pocotaica. *Boliviensis* is probably a true *Orthis*. This genus ranges from late Lower to Middle Ordovician. *Pompeckji* may be grouped with *Calymene tristani* in *Synhomalonotus*, and *krugeri* is allied to *Trinucleus ornatus* which, in turn, is found together with *Synhomalonotus tristani* in France. Thus, the two

trilobites seem to have some affinity with the Arenig of France.

Hoekaspis matacensis occurs in a red quartzite at Mataca and Cerro Pocotaica, and *Hoekaspis mesops* in a chocolate coloured shale at La Glorietta, Sucre. As the lithic aspects are quite distinct from any other rocks in the collection, and as *Hoekaspis* is a new genus, nothing definite can be said of their chronology. The general appearence of the trilobites, however, impressed me as possessing undeniable similarities with the early asaphids. Hence, *Hoekaspis* sandstone and shale might belong to the Arenigian or a period slightly younger.

Not only *krugeri* faunule, but also *Pseudobasilicus* (?) *liquensis*, *Ormoceras bolivianum* and *Endoceras* spp. are found in the geode-shale, but I wonder if the latter assemblage does not indicate the higher horizon of the shale. Three species of endoceroids were collected at Sivingomayo, Sucre, and S. Lucas, but in such a poor state of preservation as to render exact determination impossible. Howerer, every one of them has a large siphuncle, marginal or submarginal, but no wide ventral flattening such as is commonly seen in the Chikunsan endoceroids. Bolivian endoceroids are, in my belief, ceriainly not older than the Canadian age, hence it is probably in order to place them in the Chazyan or younger. *Ormoceras bolivianum* of Quechisla, near Uyuni, is also not older than the Chazyan.

Pseudobasilicus liquensis is found in a boulder or concretion at Sivingomayo. Since this trilobite, together with *Basilicus* aff. *tyrannus* and *Parabasilicus* aff. *typicalis* of Pilcomayo, suggest affinity with the Chikunsan, the age of this trilobite fauna is presumed to be Llandeilian. *Gomphoceras* (?) sp. is recorded from Pilicomayo, but if it is associated with these asaphids, I, with Hoek, question the generic reference of this cephalopod.

Parabasilicus aff. *typicalis* Kobayashi occurs on the pass Escaleras, south of Mataca and in the upper course of the Pilcomayo; *Basilicus* aff. *tyrannus* (Murchison) at Taquina, San Juan, near Tarija, south of Escaleras in the upper Pilcomayo area and on the pass Escaleras (spring area of the Pilcomayo.)

As I have just discussed, the geod-shale possibly ranges from the Arenigian to Llandeilian, and several horizons are contained in it. The *pompeckji* shale, and probably also the *Hoekaspis* shale and quartzite, may be in the lower portion and the rest in the upper. The "Knollenschiefer" of Obispo contains *Diorthis obispoensis* and

Cycloceras grecicostatum and may possibly be also the upper geode fauna.

In a boulder or concretion from Puncta Arce, *Dinorthis obispoensis* is associated with an indeterminable cycloceroid and pelecypod.

15. Cochabamba.

Nucula sp.	[*Ctenodonta cochabambensis* KOBAYASHI]

16. *Lingula* shales in northeast Bolivia

a) Palca del Tuari near Cochabamba

Homalonotus sp.	[*Homalonotus* (*Brongniartella* ?) *bistrami* HOEK]
Lingula münsteri D'ORBIGNY	
Cruziana cfr. *furcifera* D'ORBIGNY	
Orthis sp.	
Lingula cfr. *rouaulti* SALTER	
Siphonotreta sp.	
Tunaria cochabambina HOEK	
Pizarroa quichuana HOEK	

b) Molino, east Cochabamba

Lingula münsteri D'ORBIGNY
Lingula boliviensis HOEK

c) Combate near Tarabuco, Southeast Surce.

Lingula münsteri D'ORBIGNY
Lingula lineata HOEK
Lingula ellipsiformis HOEK

d) Totorapampa, Kkuri range from Mizque to Cochabamba.

Lingula münteri D'ORBIGNY	
Homalanotus bistrami HOEK	[*Homalonotus* (*Brongniartella ?*) *bistrami* HOEK]
Arca gracilis HOEK	[*Ctenodonta gracilis* (HOEK)]
Orthis cfr. *edgelliana* SALTER	[*Dalmanella* (?) sp.]
Orthis cfr. *emacerata* HALL	[*Dalmanella* (?) sp.]
Bistramia elegans HOEK	
Pizarroa quichuana HOEK	

e) Iscaipata near Cochabamba.

Homalonotus bistrami HOEK	[*Homalonotus* (*Brongniartella ?* *bistrami* HOEK)]

f) Taquina.

Lingula ellipsiformis HOEK

g) Mazocruz.

Tunaria cochabambina HOEK

h) Tambillos, upper coarse of Pilcomayo, southeast Sucre.

Lingulepis (?) sp.

Cruziana cfr. *furcifera* HOEK

i) Escaleras near Jujuy, Sierra de Zaplas.

Lingula lineata HOEK

Lingula inornata HOEK

Ctenodonta aff. *alta* HALL is found with *Ctenodonta gracilis* (HOEK) in a same specimen from Totorapampa.

The *Lingula* shale and sandstone of northeastern Bolivia contain aberrant fauna including *Lingula, Lingulepis, Tunaria, Pizzaroa, Bistramia, Siphonotreta, Dalmanellá, Ctenodonta* and *Homalonotus*. Judging from the stratigraphical relation and the occurrence of *Brongniartella*, the *Lingula* shale and sandstone may be placed in the Caradocian. Moreover, *Ctenodonta cochabambensis* quartzite shows the highest horizon in the Bolivian sequence, although it is probably still in the Ordovician.

West of Otavi we find sandstones containing faunas as tabulated.

Fossil \ Specimen	A specimen	B specimen	C specimen	D specimen
Diplograptus whitfieldi HALL?	×			
Orthis otaviensis KOBAYASHI		×		
Ctenodonta iclensis KOBAYASHI	?			
Ctenodonta mesambonata KOBAYASHI			?	×
Cleidophorus(?) aff. *consuetus* ULRICH			×	
Goniophorina isbergi KOBAYASHI			×	
Goniophorina(?) *otaviensis* KOBAYASHI				×
Leiostegina inexpectans KOBAYASHI	×	×	×	
Technophorus otaviensis KOBAYASHI		×		

The sandstone of Cuesta de Icla contains *Ctenodonta iclensis* and *Ctenodonta iclensis angusta*; and the sandstone of Tambillos, *Goniophorina tambillosensis*. *Technophorus*, however, is the most interesting of all, seeing that this is the first occurrence of ribeirioid in this continent. Furthermore, this genus is so far confined to the Upper Ordovician from the Trenton upward in North America. BULMAN

states that the determination of *Diplograptus whitfieldi* is difficult to confirm, but these pelecypod-bearing sandstones may approximately be the southern equivalent of the *Lingula* shale and sandstone. As the sandstone of Cuesta de Icla is cross-bedded and contains monotonous pelecypod fauna, mostly the convex side above in the rock, I infer that the sandstone of Cuesta de Icla is a delta facies, while the prolific fauna bearing sandstone from the west of Otavi shows the normal coastal facies.

In 1931, KOZLOWSKI[1] studied a collection from the Jatunacaca mine, east of Cerro Leque, 4 km. southeast of Colcha railway station on the Oruro-Cochabamba line, Bolivia. The collection was probably from the *Lingula* shale. He distinguished the following four species in it.

Andobolus jackowskii KOZLOWSKI
Lingula balderrami KOZLOWSKI
Lingula amygdala KOZLOWSKI
Orbiculoides jatuncacae KOZLOWSKI

In the quartzite intercalated in the shale at the Tucsuhuma mine, near Jatunacaca, he found two fragments of Orthids resembling *Orthis, Nicolella, Plectorthis* or *Diorthis.* Furthermore, to the Capinota fauna already studied by HOEK, KOZLOWSKI added two species, *Orbiculoidea capinotae* KOZLOWSKI and *Bistramia oboliformis* KOZLOWSKI.

From a study of these inarticulate brachiopods, he came to the conclusion that *Pizarroa* and *Tunaria* are synonyms of *Bistramia*, emphasizing that the asymmetrical outlines of the two genera may not signify concrete generic nature. He, moreover, suggested that among D'ORBIGNY's four species from Bolivia, namely, *Lingula marginata, L. münsteri, L. dubia,* and *Orthis humboldti,* the third belongs to *Bistramia.* Since his comments on KAYSER's and HOEK's Neotremete brachiopods are cited elsewhere, it will not be repeated here.

The following year, BULMAN[2] made an extensive revision of the graptolite list with special reference to NORDENSKIJÖLD's collections. He established the following zonings:

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1) KOZLOWSKI (1930), Op. cit.
2) BULMAN (1931), Op. cit.

Geological age	Fossils	Locality
Middle or Upper Caradocian	*Dicranograptus nicholsoni* *Orthograptus truncatus* cfr. var. *pauperatus* *O.* cfr. *calcaratus* var. *basilicus* *Triarthrus* cfr. *eatoni* *Caryocaris acuta* *Schizocrania* aff. *filosa*	Peru: Huichiyuni. Bolivia: between Crucero and Santa Cruz, between Pata and Crucero
Llandeilian	*Climacograptus bicornis* *Orthograptus* cfr. *calcaratus* var. *acutus*, *Glossograptus ciliatus* *Lasiograptus harknessi* var. *costatus* ? *Didymograptus* aff. *sagitticaulis*	Peru: Cochachinche, Chaquimayo, Monte Bello Argentine Republic
Upper Llanvirnian	*Didymograptus murchisoni* *D. murchisoni* var. *geminus* *D. stabilis* Phyllograptids *Glyptograptus dentatus* mut. *Amplexograptus* cfr. *confertus* *Lasiograptus* *Glossograptus holmi*	Peru: Chaquimayo ? Bolivia: Korpa, Tuiche, between Mojos and Capamitas, Masealayta, between Capamitas and Puina, ? Tacopaya, etc.
Lower Llanvirnian	*Didymograptus* aff. *bifidus* *D. stabilis* *D. artus* *Tetragraptus* *Triarthrus* aff. *fischeri*	Peru: Chaquimaya Bolivia: Cule, Korpa, between Capamita and Puina
Arenigian	*Didymograptus nitidus*	Bolivia: Tarija Argentina: Portezuelo
Tremadocian	? *Dictyonema flabelliforme*	Bolivia: Tarija

He writes: "it is somewhat remarkable that the multiramous Dichograptids and the Phyllograptids have such a high stratigraphical position, but the discrepancy is less when comparison is made with the Lower Ordovician faunas of eastern North America and Australia than with those of Europe. Of interest also is the balance of Eu-

ropean and North American characters in the fauna represented. A European feature is to be found in the occurrence of *Didymograptus murchisoni* and its variety *geminus*, and in the general nature of much of the Llanvirnian and Caradocian faunas, while North American influence is shown in the highest Llanvirnian, and the long range of many of the early Ordovician species. The absence of *Corynoides* is remarkable, as this constitutes such an important member of the Canajoharie fauna and of that of the *D. clingani* Zone of Nothern Europe, and this supports the view that the Caradocian horizon may approximate more closely to that of the Utica shale than the underlying Canajoharie."

That the Middle or Upper Caradocian graptolite shale may approximate the *Bilobites* and *Lingula* sandstone of STEINMANN and HOEK, is suggested by BULMAN, with which my conclusion presented in the preceding page agrees.

In addition to a great number of graptolites, more than fifty species in all, he distinguished the followings:—

1) Atremete brachiopod indt.
2) "*Orthis*" 4 spp.
3) Nautiloidea indt.
4) *Schizocrania* aff. *filosa* (HALL)
5) *Endoceras* (?) sp.
6) *Caryocaris acuta* BULMAN
7) Asaphid indt.
8) *Saukia* (?) sp.
9) *Triarthrus* cfr. *eatoni* (HALL) em. RUEDEMANN
10) *T.* aff. *fischeri* BILLINGS
11) *Trinucleus nordenskijöldi* BULMAN
12) Trilobites, 4 spp. gen. et. sp. indt.

It is interesting to note that *Lingulocaris* cfr. *acuta* (BULMAN) has been reported by CHAPMAN[42] from Horizon C_4, Cape Province section of New Zealand.

Subsequently, in 1933, additional graptolite materials from the Yuscamayo and Yunahurco rivers, Eastern Peru, were presented by

1) F. CHAPMAN (1934), On some Phyllocarids from the Ordovician of Preservation Inlet and Cape Province, New Zealand, (Trans. Roy. Soc. New Zealand Vol. 64.)

DOUGLAS[1] to BULMAN. The faunas constitute an assemblage of Upper or Middle Llanvirnian age. The non-graptolite faunas of the Quitari area are described by DOUGLAS, composed of the following species :—

1) 2 species of the Endoceratidae, of which one probably belongs to *Cyclendoceras*.
2) Orthoceratidae similar to *Geisonoceras tenuistriatum* HALL
3) *Leptobolus insignis* HALL mut. *latus* RUEDEMANN
4) *Schizocrania* aff. *filosa* (HALL)
5) *Orthis*, gen. et sp. indt.
6) *Homotelus* sp. similar to *H. stegops* (GREEN)
7) *Asaphus* sp. indt.
8) *Triarthrus* spp. probably identical with *Triarthrus* aff. *fischeri* BILLINGS described by BULMAN from Korpa
9) *Trinucleus* sp.

On looking at Fig. 2, Pl. XXIX, I wonder whether DOUGLAS' *Endoceras* sp. might not be a fragment of asaphid composed of eight thoracic segments and a part of the cephalon or pygidium.

During my stay at the U. S. National Museum, Washington, D. C. I[2] studied and described KEIDEL's collection from Prairie Catamarca, which consists of the following species :—

Eoorthis (?) *putilliformis* KOBAYASHI	[*Orusia putilliformis* (KOBAYASHI)]
Oxydiscus keideli KOBAYASHI[3]	
Agnostus sp.	
Kainella meridionalis KOBAYASHI	
Kainella conica KOBAYASHI	
Kainella lata KOBAYASHI	
Andesaspis argentinensis KOBAYASHI	
Asaphellus catamarcensis KOBAYASHI	[? *Asaphellus* (*Asaphelloides*) *americana* (HOEK)]

This generic assemblage, notably the inclusion of the three species of *Kainella*, points to the fact that this fauna, which may be

1) J. A. DOUGLAS (1933), The Geology of the Marcapata Valley in Eastern Peru with an appendix on the Graptolites by D. M. B. BULMAN, (Quart. Jour. Geol. Soc. London Vol. LXXXIX), pp. 308–353, pls. XXVII-XXXIII.

2) KOBAYASHI (1935), Op. cit.

3) The reader is requested to read *Oxydiscus keideli* for *Oxynodiscus keideli* in my paper published in 1935, (Op. cit.)

equated to the *Kainella* zone of North America, marks the basal Ordovician of a distinct eastern Pacific tint.

Later Dr. Tomas M. Ezcurra, Directer of the Bureau of Mines and Geology of the Argentine Republic, sent me another collection made from the black shales of Quebrada de Humahuaca, province Jujuy, collected by Prof. Hans Keidel. This faunule[1] contains

Eoorthid, gen. et. sp. indt.
Parabolinella argentinensis Kobayashi, and
Jujuyaspis keideli Kobayashi.

This is a small but extremely interesting fauna, for the reason that it is, with remarkable contrast to the *Kainella* fauna, typical of the Atlantic Olenid fauna. In the meantime, I had an opportunity of looking over still another collection that was procured by Dr. John S. Brown from Cajas, 15 miles west of Hambacca, Argentina. This collection includes

Acrotreta sp.,
Schizambon sp.,
Finkelnburgia (?) aff. *F.* (?) *saishoensis* (Kobayashi),
Agnostus sp. aff. *A. chushuensis* Kobayashi,
Apatokephalus sp. (nov.),
Leiostegium sp. (nov.),
Shumardia cfr. *dicksoni* Moberg [*Shumardia erquensis* Kobayashi],
Asaphellus aff. *gyracanthus* Raymond and
Hystricuroid (?) sp. (Gen. et. sp. nov.)

From the assemblage of *Apatokephalus*, *Leiostegium*, *Shumardia*, and *Asaphellus*, the fauna may certainly be placed in the Lower Ordovician age, while *Leiostegium* is characteristic of the North American or Eastern Pacific Province.

From palaeontological evidences, these faunas may be arranged in the following order.

Zone	Age	Faunal province
Parabolinella Zone	Late Upper Cambrian	Atlantic
Kainella Zone	Early Tremadocian.	Eastern Pacific
Leiostegium Zone	Late Tremadocian.	

1) Kobayashi (1936), Op. cit.

III. Summary and Palaeogeography.

Except for the *Peltura* shale of province Caupolican, Bolivia, the main distribution of the Cambrian formation is in the boundary regions between Bolivia, and Argentina. According to field observations made there by STEINMANN,[1] KEIDEL,[2] HAUSEN[3] and others, there is considerable difference in the intensity of the disturbances by which the Pre-Cambrian and Cambro-Ordovician formations have been suffered. Clear-cut unconformities are observable at places where the Cambrian lies on the denuded surface of the folded Pre-Cambrian basement. Morover, the nature of the Cambrian basal conglomerate testifies to the discordance between the two complexes.

STEINMANN distinguished two beds in the Cambrian strata of the southeastern Bolivian Highland, namely, the lower non-fossiliferous grayish blue or reddish gray quartzite with ripple marks and the upper or fossiliferous micaceous sandstone, besides a black shale of Salitre.

KEIDEL divided the Cambrian of northern Argentina into three beds in ascending order as follows:—

I) Non-fossiliferous quartzite with ripple marks.
II) Fossiliferous hard and variegated shale with many intercalations of sandstone.
III) Dark coloured clayslate.

As the Upper Cambrian faunas described by KAYSER were procured from KEIDEL's middle division, they may be correlated with STEINMANN's upper division, or, at least, with the lower part of it, both being characterized by "*Olenus*" *argentinus*. The *Parabolinella* shale of Purmamarca, which came from KEIDEL's upper division, is in latest Upper Cambrian, and may be close to the *Parabolina* shale of Salitre.

It is, however, yet a question whether KEIDEL's middle division corresponds exactly to STEINMANN's upper division or only to the

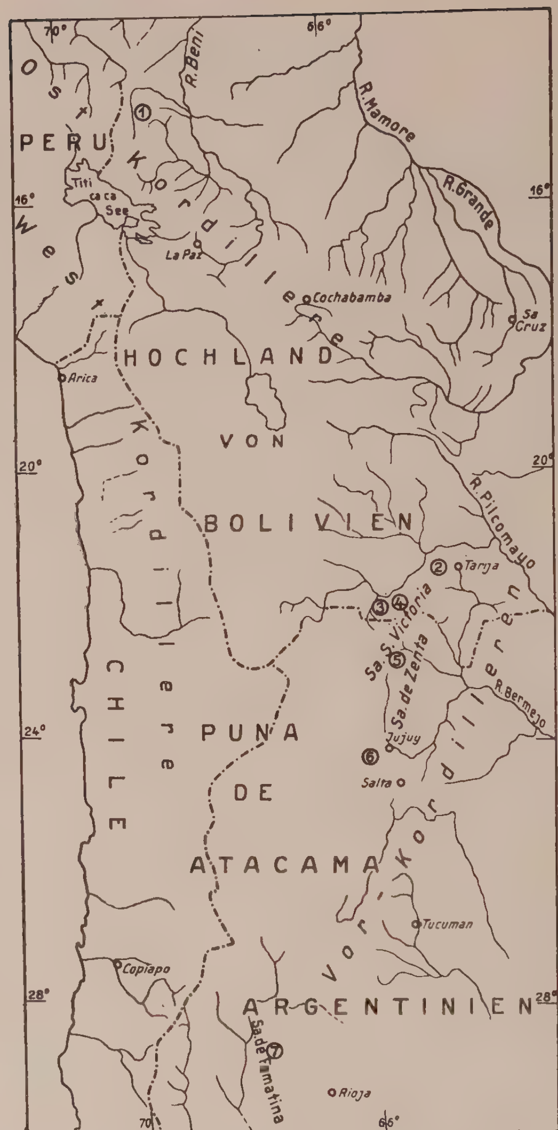
1) STEINMANN and HOEK (1912), Op. cit.

2) H. KEIDEL (1907), Über den Bau der Argentinischen Anden, (Sitzungsber. d. k. Akad. d. Wiss. math-naturw. Kl. 116, Wien.)

3) H. HAUSEN (1930), Geologische Beobachatungen in den Hochgebirgen der Provinzen Salta und Jujuy, Nordwest Argentinien, (Meddel. Från Åbo. Akad. Geol. Min. Inst. Nio 11.)

lower half of the upper divison. Furthermore, the upper half of the division may be contemporaneous with, but different in facies from, the *Parabolinella* shale of Purmamarca. If the former were the case, some sort of erosion should be expected between the Cambrian and Ordovician in the Bolivian Highland, but field observations do not support such a contingency, even palaeontological evidences strengthening the latter alternative, seeing that the sandstone of Tambo Guanacuno contains no "*Olenus*?" *argentinus*, but *Jujuyaspis*.

As HAUSEN has said, the Cambrian



Map 1. Cambrian fossil localities in the South American Cordilleras.

1. Cochaiya, 5 km. northeast of Pata on the way to Apollo, Caupolican.
2. Cuesta de Escayache, west of Tarija, on the south of two roads of the Pass, 1½ hour's walk west of the pass and at Tambo Guanacuno, further on the northwestern river of Co. Campanario, east of Pampa de Tascará.
3. Salitre on the boundary between Argentina and Bolivia, northeast of the Quiaca.
4. Tilcuya in the same region, a little farther northeast on the way to Tarija.
5. Iruya and Ojo de Agua in the northern part of Province Salta.
6. Nevado de Castillo and Nevado de Chani, west of Jujuy.
7. Las Juntas on the Rio Achavil and El Volcancito on the Rio del Marco in the northern part of Sa. Famatina. [After GERTH (1932)]

strata are mostly regarded as epicontinental deposits. The dominant ripple marks and the clastic nature of the rock suggest that the sediment was accumulated in the shallow and quiet sea close to the Pre-Cambrian landmass. The black shale in the high horizon of the sequence, on the other hand, might be taken for the bathyal facies, as was thought by GERTH. Except for the Province of Caupolican, this facies is so far confined to the area between Purmamarca and Salitre.

The Ordovician formation in this continent is extensively distributed from the state of Zamara in Venezuela to Mendoza in Argentina over a distance of more than 5,300 km. In his paper on the Cambro-Ordovician of the Bolivian Highland, STEINMANN wrote, "ein bemerkenswertes kennzeichen der cambrischen und silurischen Sedimente ist ihre Kalkarmut, besonders in Bereiche der bolivisch-peruanischen Kordillere," and further, "neben Trilobiten, hornschaligen Brachiopoden und Graptolithen nur ganz ausnahmsweise Organismen mit kalkreicher Schale auftreten, wie Cephalopoden, Lamellibranchiaten, kalkschalige Brachiopoden und Crinoiden; Korallen und Bryozoen scheinen so gut wie ganz zu fehlen."

Evidences so far available support his view regarding the northern Andes. The non-calcareous Ordovician complex is developed in Peru and Colombia.

The Arenigian graptolite fauna of Columbia was made known by HARRISON[1] and ELLES. The Ordovician of Venezuela was first reported by DREVERMANN[2] with descriptions of *Calymene senaria* and *Orthoceras* cfr. *olornus*. Later, however, their sources became doubtful.[3] Thanks to TERRY and LEITH,[4] the existence of the Ordovician in that country is now fully established. In TERRY's collection from the state of Zamora, LEITH distinguished *Dicranograptus caparroensis* and *Cryptolithus terryi*. Since the former is allied to *D. ramosus* and the latter to *C. caractaci*, the faunule is believed to be of the Glenkiln upper Normanskill-lower Hartfell formations.

Graptolite shales are known to occur in Peru, from which *Cruziana carranze* BALTA (i. e. *C. furcifera* D'ORBIGNY) and *Lingula attenuata*

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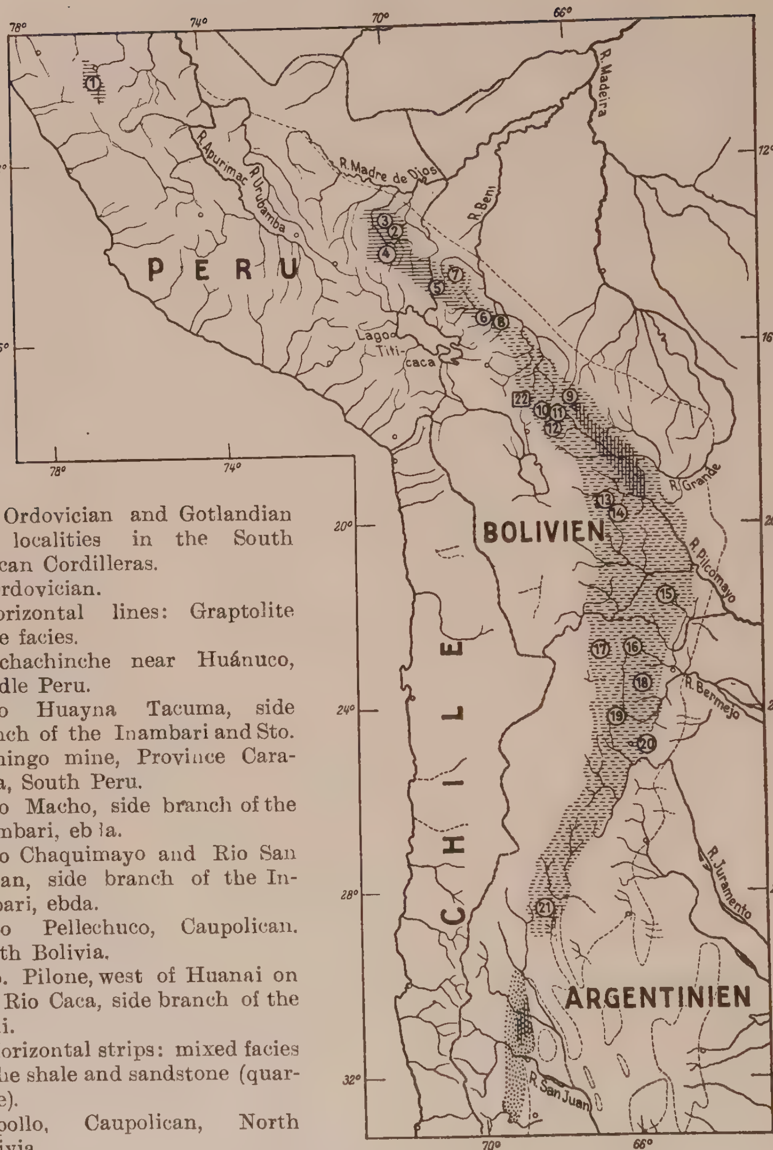
1) J. V. HARRISON (1930), The Majdalina Valley, Columbia, South America, (15th Intern. Geol. Congr. South Africa, Compt. Rend. Vol. 2.)

2) Fr. DREVERMANN (1904). Über Untersilur in Venezuela, (Neuse Jahrb. 1904, I).

3) W. SALAMON (1909), Über angebliches Untersilur in Venezuela, (Zeitsch. deutsch. geol. Gesell. 61 Bd.)

4) C. SCHUCHERT (1935), Historical Geology of the Antillean-Caribean Region, p. 694.



Map. 2 Ordovician and Gotlandian fossil localities in the South American Cordilleras.

A. Ordovician.

a) Horizontal lines: Graptolite shale facies.

1. Cochachinche near Huánuco, Middle Peru.
2. Rio Huayna Tacuma, side branch of the Inambari and Sto. Domingo mine, Province Carabaya, South Peru.
3. Rio Macho, side branch of the Inambari, ebda.
4. Rio Chaquimayo and Rio San Gaban, side branch of the Inambari, ebda.
5. Rio Pellechuco, Caupolican. North Bolivia.
6. Co. Pilone, west of Huanai on the Rio Caca, side branch of the Beni.

b) Horizontal strips: mixed facies of the shale and sandstone (quartzite).

7. Apollo, Caupolican, North Bolivia.
8. Rio Caca, side branch of the Beni, upper half of the mouth of the Rio Coroico.
9. Palca de Tunari, North Cochabamba.
10. Cuesta Tapacari, West Cochabamba.
11. Co. Pocotaica near Capinota.
12. Jatunacaca mine, Southeast Colcha.
13. Escalera-pass on the way from Potosi to Pilcomayo.
14. Vicinity of Otavi, Southeast Potosi.

15. Cuesta de Erquis, west Tarija in the Cordilleras of Escayache.
16. Co. Fundiciones near Cienega, Southwest of Sta. Victoria, North Argentina.
17. Tambo Queta, Northwest Cochinoca, Province Jujuy, North Argentina.
18. Mudaue, Northeast Tilcara, Province Jujuy,.
19. Agua Calientes in the Quebrada de Reyes, West Jujuy.
20. Portezuelo near Salta.
21. Las Conchas, Rio de la Hoyada, West Los Angulos in the northern part of the Famatina range.

c) Points: Calcareous and dolomitic facies in the Fore-Cordilleras of San Juan and Mendoza.

B. Gotlandian.

Vertical lines: Distribution of the *Clarkeia antisiensis* bearing formation.? Gotlandian with *Monograptus* (BALTA)

22. ? Gotlandian with *Climacograptus* from the San Roque-mine on tho western slope of Sa. Sta Vela Cruz, Bolivia. [After GERTH (1932)]

SOWERBY are listed, besides a number of graptolites.[1] The graptolite and *Lingula* shales and *Cruziana* sandstones are widely distributed in northeastern Bolivia. They extend, moreover, southward and merge into the sandstones and shales in southeastern Bolivia and adjacent Argentina, where these rocks contain rich shelly faunas and compose the main part of this study.

Limestone and calcareous shale have already been found at Cajas, west of Hambacca, which yield *Leiostegium* fauna. From Sa. de Famatina come the greywacke and shale with the Ordovician trilobite fauna. Besides these, BODENBENDER[2] discovered in the lower horizon an *Obolus* and *Agnostus*-bearing limestone bank interbedded with shales in the valley of the Río Valcancite, and *Dictyonema flabelliformis* EICHWALD and *Staurograptus dichotomas* EM. bearing black shale of Peñón Negro in the upper Río Achavil. These graptolites suggest the Tremadocian age of the shale.

The calcareous facies reveal a still greater display in the south, namely, in the San Juan and Mendoza regions which, since KAYSER's study, have been well known by the name of San Juan limestone.

This may be the southernmost limit of the fossiliferous Eo-Palaeozoic formation in South America, excepting the South Orkney Island in the Antarctic Ocean, where *Pleurograptus* and *Discinocaris*, presumably Middle Ordovician, were found in the phyllitic shale.

As shown in the annexed chart from his Geologie Südamerikas,

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1) G. STEINMANN (1929), Geologie von Peru, Heidelberg, p. 16.

2) G. BODENBENDER (1922), El Nevado de Famatina, (An Direcc. Gener. de Minas, Tom. XVI, No. 1), p. 36.

(See Map 2), GERTH[1] distinguished the Ordovician formations of the continent into three facies, namely,

1) the graptolite facies dominating in the north,
2) the sandstone, shale, and quartzite facies in the middle, and
3) the limestone and dolomite facies in the south, i. e. in the Fore-Cordillera of San Juan and Mendoza.

The three facies, however, merge into one another to a certain extent, both horizontally and vertically.

In summarizing the discussions in the preceding chapter, the Cambro-Ordovician sections may tentatively be correlated as done in the table inserted here.

In the Lower Cambrian period the Continent presumably followed the usual continental history. Neither the typical Paradoxidian nor the Middle Cambrian fauna of the Pacific province have as yet been discovered there except for the "*Liostracus*" *steinmanni* fauna of Iruya in Province Salta which, as already discussed, has not been definitely proved to be of the Middle Cambrian age.

The presence of the Upper Cambrian strata, on the other hand, is beyond question. That the Upper Cambrian Sea has transgressed over the Andine terrane of the Pre-Cambrian complex and has deposited there the epicontinental clastic sediment, agrees with the status determined in the Mississippi valley. The middle continent of North America was an extensive flat land between the Cordilleran and Appalachian troughs, which in turn, followed the marine history all through the Cambrian age, whereas the middle continent was only flooded by sea-water in the Upper Cambrian period.

In the Upper Mississippi valley is the type locality of the Croixan series,[2] which is divided into three formations in ascending order as follows:—

Dresbach formation
Franconia formation
Trempealeau formation

The Dresbach contains the *Crepicephalus* and *Cedaria* zones. From the Franconia to the Trempealeau, the trilobite faunas gra-

1) H. GERTH (1932), Geologie Südamerikas, (Geologie der Erde), I Teil.

2) W. H. TWENHOFEL, G. O. RAASCH and F. T. THWAITES (1935), Cambrian Strata of Wisconsin, (Bull. Geol. Soc. America Vol. 64.)

Table showing the Cambro-Ordovician

Europe	Northern Part Mainly graptolite facies	Middle Part Mainly shale and sandstone facies
Ashigillian	Upper *Scolithus* quartzite (*Ctenodonta cochabambensis* quartzite of Cochabamba)	
Caradocian	*Lingula* shale (D'ORBIGNY, STEINMANN, ULRICH, HOEK, KOZLOWSKI) Middle and Upper Caradocian graptolite shale *Cryptolithus terryi* shale and sandstone in Venezuela	*Leiostegina-Goniophorina* sandstones of Otavi *Ctenodonta* sandstone of Cuesta de Icla *Goniophorina* sandstone of Tambillos
Llandeilian	*Cruziana* sandstone Llandeilian graptolite shale Upper Llanvirnian graptolite shale	*Ormoceras bolivianum* sandstone of Uyuni Endoceroid sandstone of Sivingomayo, Sucre a *Basilicus-Parabasilicus* sandstone of Pilcomayo, *Pseudobasilicus liquensis* shale of Sivingomayo *Diorthis obispoensis* shale of Obispo
Arenigian	Lower Llanvirnian graptolite shale *Lakaspis apolinista* sandstone of Apolo *Ogyginus-Niobella* shale and sandstone of the River Caca	*Trinucleus krugeri* shale of Cerro Pocotaica *Hoekaspis mesops* shale of La Glorietta, Sucre *Hoekaspis matacensis* red quartzite of Mataca a Middle quartzite *Didymograptus nitidus* shale of Angustura de Q
Tremadocian		*Parabolinopsis mariana* white shale of Cuesta d *Dictyonema* shale of Cuesta de Erquis *Kainella* shale and sandstone of northeastern *Finkelnburgia samensis* shale and sandstone of Lower Quartzite
Late Olenidian	*Peltura* shale of Cochaiya	*Parabolina andina* black shale of Salitre *Jujuyaspis keideli* black shale of Humahuacca *Jujuyaspis steinmanni* sandstone of Tambo Gua *Plethopeltis* sandstone of Pampa de Tacsara, Al
Early Olenidian		" *Olenus* " *argentinus* sandstone of Tilcuya and " *Liostracus* "-*Phalacroma* sandstone of Iruya Gray non-fossilifer ous basal quartzite

* For the emendation of the Ozarkian, see T. KOBAYASHI, (1932–33), The Ozarkian Question and my View, (Jour. Geol. Soc. Japan, Vols. XL–X

aunal Successions in South America

	Southern Part Mainly calcareous facies	North America
		Mohawkian
	[*Pleurograptus* shale of South Orkney Island]	Cincinnatian
l S. Lucas te.	Fauna of Cerro del Fueroo Fauna of Quebrada de Talacastra Fauna of Guaco	Chazyan
Fauna of Potrero de los Anglos l Cerro Pocotaica ? *Riograndella subcircus* sandstone of Ciudod ta *Megalaspidella* sandstone of Mudana *Thysanopyge-Xenostegium* sandstone of Salta	San Juan Limestone Fauna of Quebrada de Juan Podre	Beekmantown proper
Escayache *Leiostegium* limestone of Hambacca *Dictyonema* shale of Peñón Negro olivia and Prairie Catamarca in Argentina uesta de Sama. ? *Orusia saltensis* sandstone of Aguas Calientes, Salta, Nevado de Castillo and Ojo de Agua	Fauna of Quebrada de la Laja	Ozarkian em.*
Obolus-Agnostus limestone of the Río Volcancito acuno		Late Croixan
a de Chorcoya and Tilcuya uesta de Escayache		Early Croixan

.I.)

dually charge, although both totally distinct from the Dresbach fauna. "*Olenus*" *argentinus* which resembles *Crepicephalus*, might suggest faunal affinity with the Dresbach, but until the associated pygidium of this trilobite is discovered the evidence is not conclusive. Owing to the common occurrence of *Plethopeltis*, which is spread over the Trempealeau and its contemporaneous formations in the central and eastern regions of the North American continent, the communication of faunas between South and North America can hardly be overlooked.

The occurrence of typical olenids, such as *Parabolina*, *Parabolinella*, and *Peltura* are very striking features of the South American fauna. Through these genera, it may be ascertained that the Andine sea was confluent with the Atlantic in the late Upper Cambrian. These trilobites, however, are all spiny forms, and their distribution is confined to the bathyal facies of black shale in South America.

Incidentally, *Parabolinella* (?) *evansi* KOBAYASHI has been an enigmatic fossil in British Columbia. Being accompanied by *Agnostus* of the *reticulatus* group, the Atlantic camplexion of the faunule is quite evident. But then, how such a stranger could have straggled into the northern Pacific area is a mystery. As was discussed in my previous paper[1], most of the trilobites of olenids known outside of the Atlantic province are not true olenids, except those in British Colombia and South America. The Olenidian trilobites, which are characteristic of the Atlantic provinces, may be traced from northern Europe to the maritime provinces of North America. *Olenus* cfr. *truncatus* has been reported from Cedar Bluff, Alabama, but it belongs neither to BLUNNICH's species nor to *Olenus* s. str. Only through *Glyptagnostus* cfr. *reticulatus* can we recognize an affinity between this Alabama fauna and the Atlantic fauna.

The Olenidian fauna is replaced in North America by the *Crepicephalus-Cedaria* fauna in the lower Croixan age and the dikelocephalid fauna in the middle and upper Croixan; in eastern Asia by the *Chuangia* fauna in the Changshanian and the *Tsinania* fauna in the Fengshanian[2]; and by the *Koldinia-Orlovia* fauna in the Arctic pro-

1) KOBAYASHI (1936), Op. cit.
2) T. KOBAYASHI (1933), Upper Cambrian of the Wuhutsui Basin, Liaotung, with Special Reference to the Limit of the Chaumitian (or Upper Cambrian) of Eastern Asia, and its Subdivision, (Japan. Jour. Geol. Geogr. Vol. XI.)

vince.[1] Therefore, no route has been left for Atlantic *Parabolinella* to migrate into British Columbia, except through the Andine Sea. I, therefore, imagine that there was a channel on the eastern side of the Appalachian landmass that extended from western Europe to the Andes. The sea-water of this Atlantic channel was sometimes flooded over, with the result that the Olenidian trilobites found it possible to straggle into the Alabama embayment at one time and into the Andine Sea at another, and in some rare instances even reached British Columbia. This hypothetical journey is certainly long, but it is the only one now conceivable.

The Olenidian trilobites survived through the *Kainella* stage until the *Parabolinopsis* shale in South America. In the meantime *Kainella* developed considerably in the southeastern Pacific regions. Since *Plethopeltis megalops* is contained in the *Kainella* bed, it is an exceptional survivor of the Upper Cambrian. Moreover, the *Kainella* bed indicates the very base of the Ordovician, followed later by the *Dictyonema* shale.

In Scandinavia, on the other hand, the *Dictyonema* shale is at the base of the Tremadocian, which is succeeded by the *Ceratopyge* limestone in the upper horizon in which is contained *Apatokephalus*, the genus occurring in Argentina in the *Leiostegium* fauna.

In a section of Squaw Mountain,[2] near the Yukon-Alaska boundary, *Symphysurina spicata* is found associated with brachiopods common in the *Briscoia* fauna of adjacent Alaska,[3] so that this horizon might be Upper Cambrian. *Symphysurina*, as a genus, is distributed, however, mainly in the basal Ordovician or late Ozarkian of ULRICH,[4] in the northern part of North America, whence it spread to Greenland.[5] In British Columbia the *Symphysurina* zone is under-

1) T. KOBAYASHI (1935) Difference of the Zoopalaeogeographic Province between the Upper Cambrian and Lower Ordovician Periods, (Jour. Geol. Soc. Japan Vol. 42.)

2) T. KOBAYASHI (1936), Cambrian and Lower Ordovician Trilobites from Northwestern Canada, (Jour. Palaeont. Vol. 10, No. 5.)

3) T. KOBAYASHI (1935), The *Briscoia* Fauna of the late Upper Cambrian in Alaska with Descriptions of a few Upper Cambrian Trilobites from Montana and Nevada, (Japan. Jour. Geol. Geogr. Vol. 12.)

4) T. KOBAYASHI (1933-34), The Ozarkian Question and my View (Jour. Geol. Soc. Japan Vols. 40-41.)

5) C. POULSEN (1927), The Cambrian, Ozarkian and Canadian Faunas of Northwest Greenland, (Jubilaemuseekspeditionen Nord om Grønland, 1920-23, No. 2.)

neath the *Kainella* zone,[1] but the two trilobites are found in the same bed in the Eureka District of Nevada.[2] Thus, *Symphysurina* is the northern origin and *Kainella* the southern. The relation between the two trilobite zones in British Columbia may indicate the time displacement involving the migration. The *Parabolinopsis* shale, is, if STEINMANN's stratigraphy is correct, higher than the *Dictyonema* shale and has a very limited distribution. The trilobite, which is an endemic form of this area, is indeed the latest survivor of the Olenidae. The fine compact nature of the shale might suggest the bathyal facies of late Tremadocian, where the Olenidae find shelter, but sooner or later the evolutional line dies out with the shale. Of Pacific life, the *Leiostegium* and *Xenostegium* faunas succeed the *Kainella*. *Leiostegium* may be the northern origin, it being probably linked with *Chuangia* through *Chuangiella* in the *Briscoia* zone of Alaska. *Leiostegium* is accompanied at Cajas by *Apatokephalus*, and the age of its fauna may be late Tremadocian. In British Columbia, *Xenostegium* occurs not only in the *Xenostegium* zone itself, but in the *Ozarkiospira* zone, which lies between the *Xenostegium* and *Kainella* zones.[3] The fauna may not be very much older than that indicated by the *Leiostegium* fauna.

In contrast to these Pacific Trilobite faunas, the *krugeri* fauna of Cerro Pocotaica appears to suggest some affinity with the Arenigian fauna of France and Portugal.

The rest of the faunas of the geode shale do not exhibit much of a provincial aspect. The occurrence of *Technophorus* in the environs of Otavi is interesting because it indicates faunal affinity with the Upper Ordovician of North America.

Finally it may be noted that the Cambro-Ordovician sea in the Bolivia-Argentina border land was mostly epicontinental and presumably attended by some kind of a sea-saw movement. The situation naturally complicates Cambro-Ordovician palaeogeography, because the invasion of the fauna came from the Pacific side at one time and from the Atlantic at another. The history is therefore tangled,

1) D. WALCOTT (1924), Geological Formations of Beaverfoot-Brisco-Stanford Range, British Columbia, Canada, (Smiths. Misc. Coll. Vol. 75, No. 1.)

2) C. D. WALCOTT (1923), Nomenclature of some Post-Cambrian and Cambrian Cordilleran Formation (2), (Smiths. Misc. Coll. Vol. 67, No. 8.)

3) C. S. EVANS (1933), Brisco-Dogtooth Map Area, British Columbia, (Geol. Surv. Canada Publication.)

with many questions remaining to be answered by further research, both stratigraphical and palaeontological. The answers will not only be of local interest, but will certainly elucidate the interprovincial correlations, palaeogeography, and the evolution of the Eo-Palaeozoic biota.

IV. Description of Fossils.

Seventy two species of fossils are described here, namely, 1 species of an indeterminable cystoid, 10 species of brachiopods, 2 species of gastropods, 10 species of pelecypods, 5 species of cephalopods, 41 species of trilobites, and 2 species of problematicums. Besides one new family (Macropygidae), 4 new genera, 23 new species, and one new variety are established in this paper. These new genera and their type species are as follows:—

Riograndella	*Riograndella subcircus* KOBAYASHI (nov.)
Ciceragnostus	*Agnostus barlowi* BELT
Sulcatagnostus	*Agnostus securiger* LAKE
Hoekaspis	*Megalaspis matacensis* HOEK

My special attention was drawn to *Pelagiella*, *Shumardia*, the Kainellidae and the agnostids. It is hope that the brief notes on the internal structure of *Ormoceras bolivianum* (page 435), on the difference in facies between the *Ctenodonta* and *Leiostegina* sandstones (page 428), and on an episode that occurred on the Bolivian highland during the Ordovician time (page 510) may prove of some interest.

Phylum ECHINODERMATA
Class CYSTOIDEA Leopold von Buch
Cystoid, gen. et. sp. indt.

Plate I, figures 1–2.

Of the hexagonal plates and columnar joints found on slabs of shales two forms may be distinguished. The one from the Guanacuno area is smaller than that from the Cuesta de Erquis district. The former has only one or two ridges on each triangle of the hexagonal plate, while the latter has more than three ridges. The former is, moreover, associated with *Plethopeltis megalops*, whereas the latter is connected with the *Kainella* fauna. Since all are represented by detached fragments, no exact determination can be made. As stated elsewhere,[1] these kinds of cystoid fragments are, however, known to occur in the Lower Ordovician and older formations in various localities. But these occurrences are significant in that they are the oldest cystoids known to have been discovered on this continent.

Formation and locality:—Late Upper Cambrian of Guanacuno; Basal Ordovician of Cuesta de Erquis, Tarija.

Phylum MOLLUSCOIDEA
Class BRACHIOPODA Dumeril
Order NEOTREMATA Beecher
Family Acrotretidae Schuchert
Genus ACROTRETA Kutorga, 1848
Acrotreta cfr. *curvata* Walcott

Plate I, figures 3–4

Ventral valve is a high cone with circular base except for narrow straight posterior margin; apex marginal. Internally a pair of main vascular sinuses divergent from the apex embracing a callosity in between. Dorsal valve slightly convex; well-marked small area located at posterior end which is divided into a median

1) T. Kobayashi (1935), The Cambro-Ordovician Formations and Faunas of South Chosen, Palaeontology, Pt. III, Cambrian Faunas of South Chosen with a Special Study on the Cambrian Trilobite Genera and Families, (Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. II, Vol. IV, Pt. 2,) pp. 59–60.

and two lateral parts by a pair of ridges; median ridge strong, starting at end of that area and fading out some distance from anterior margin; cardinal and central mascular scars located obliquely on both sides of septum, while anterior quarter of shell is marked by radial impressions, supposed to be accessory vascular scars.

All specimens deformed to some extent and false area and cardinal scar of ventral valve cannot be clearly seen.

So far as I can see, this species is allied to *Acrotreta curvata* WALCOTT[1] from the passage beds between the Cambro-Ordovician formations in the Eureka district, Nevada. *A.* cfr. *curvata* also occurs in the late Upper Cambrian of Yukon-Alaska boundary.[2] The specific identity, however, is uncertain, because the two pairs of muscular scars on the dorsal valve are arranged in somewhat different manner.

Formation and locality:—*Kainella* zone of Cuesta de Erquis.

Order PROTREMATA BEECHER

Family Finkelnburgiidae SCHUCHERT and COOPER

Genus ORUSIA WALCOTT, 1905

Orusia saltensis (KAYSER)

Plate I, figures. 5-7

1876. *Orthis saltensis* KAYSER, Op. cit., p. 8, pl. I, fig. 16.
1912. *Orthis saltensis* HOEK, Op. cit., p. 219.

KAYSER has already described *Orthis lenticularis* from Tilcuya (KAYSER, Pl. I, figs. 11–12,) and *Orthis saltensis* from Nevado de Castillo (pl. I, fig. 15,) and from Salta (pl. I, fig. 16). WALCOTT[3] doubted the identity of KAYSER's *lenticularis* with WAHLENBERG's *lenticularis,* the type species of *Orusia,* although they are apparently similar. The radial ribs are much coarser in the former than in the latter. *O. saltensis* from Nevado de Castillo shows an interior similar to the species from Aguas Calientes.

HOEK's *saltensis* looks similar to *Finkelnburgia samensis,* but in its internal characters is distinct from the latter.

In the ventral valve, the floor of the delthyrial cavity is not so

1) C. D. WALCOTT (1912), Cambrian Brachiopoda, (U. S. Geol. Surv. Monogr. 51,) p. 682, Pl. LXVIII, figs. 1–1n.

2) T. KOBAYASHI (1935), The *Briscoia* Fauna of the Late Upper Cambrian in Alaska with Description of a few Upper Cambrian Trilobites from Montana and Nevada, (Japan. Jour. Geol. Geogr. Vol. XII,) p. 45, pl. XI, figs. 18–20.

3) WALCOTT (1912), Cambrian Brachiopoda, p. 768.

thick and is more elongately ovate; the interior of the dorsal valve somewhat resembles that of the syntrophoid. I am inclined to believe that this belongs to *Orusia*. In surface sculpture it resembles *O. lenticularis* rather than its varieties, *atrypoides* and *lyncioides*, but the ribs are acutely angulated and finer than those of *lenticularis* s. str.

Formation and locality:—Light gray or more or less purplish quartzose sandstone of Aguas Calientes (Quebrada de Reyes), W. Jujuy. A few indeterminable lingulids are found associated with this species.

Orusia putilliformis (KOBAYASHI)

1935. *Eoorthis ? putilliformis* KOBAYASHI, Japan. Jour. Geol. Geogr. Vol. XII, p. 62, pl. XI, fig. 21–24.

Several specimens collected from Aguas Calientes can specifically be identified with this species. It is quite similar to *O. saltensis* in its external and internal features, but may be distinguished from that species by its longer and straight hinge margin. The dorsal valve has sometimes a wide sinus with a plication of medium size.

Formation and locality:—Light gray sandstones of Aguas Calientes, Quebrada de Reyes and Prairie Catamarca.

Genus FINKELNBURGIA WALCOTT, 1905

Finkelnburgia samensis, new species

Plate 1, figures 8–14

1912. *Orthis carausi* HOEK, Op. cit., p. 222.

Description:—Shell semielliptical; hinge line straight; cardinal extremity obtuse; ventral valve more convex than dorsal and slightly acuminated toward beak.

Internally, ventral valve has an open delthyrium, its delthyrial cavity deep, its floor thickened forming a pseudospondylium which continues forward to short median ridge; adductor and diductor scars of equal size; vascular sinus strong.

Dorsal valve has deep notothyrial cavity which is orthid-shaped; cardinal process develops into thick median ridge; brachiophore fused with support; adductor scars on both sides of ridge not

strongly impressed. Surface marked by fine costae.

Observation:—The specimens in shale and coarse sandstone vary to some extent. The vascular sinus and muscular scars are more distinct in the latter than in the former. This peculiarity may be explained by the fact that the former lived on a rough coast and hence a thick and strong shell was naturally required, while the latter inhabited a quiet muddy floor, the thin shell being sufficient for its existence.

Comparisons:—HOEK's *Orthis carausii* is quite distinct from *Orthis carausii* SALTER[1] in its interior characteristics. Furthermore, the ribs are coarser in *O. carausii* than in this species. The long outline of the shell and the fine costae distinguish this species from *F. osceola*,[2] *F. wemplei*[3] and *O. armanda*.[4] The obtuse extremity of the hinge line readily distinguishes it from *F. finkelnburgi*.

Formation and locality:—Coarse sandstone of Cuesta de Escayache and Cuesta de Sama; and shale of Cuesta de Sama (east side,) Southeastern Bolivia.

Family Orthidae WOODWARD

Genus ORTHIS DALMAN, 1828

Orthis boliviensis, new species

Plate I, figures 19–21

1912. *Orthothetes* sp. HOEK. Op. cit., p. 246.

Description:—Ventral valve convex; dorsal valve flat; hinge line corresponding to maximum breadth; surface marked by about 28 ribs in addition to riblet between each pair of ribs in mesial portion; interior of valve typical of orthid; delthyrium open, relatively large and right triangular in outline; dental plate subparallel; notothyrium small and open; notothyrial cavity shallow, with distinct cardinal process; brachiophore and dental socket distinct; median ridge weak.

Comparisons:—This is probably a true *Orthis*, but can be distinguished from *Orthis calligramma* and its varieties by its outline,

1) T. DAVIDSON (1864–1871), British Fossil Brachiopoda, Vol. III, (Palaeontogr. Soc.) p. 229, pl. XXXIII, figs. 17.

2) C. D. WALCOTT (1912), Cambrian Brachiopoda, (U. S. Geol. Surv. Monogr. 51,) p. 795, pl. XCIII, figs. 1–1h.

3) H. F. CLELAND (1900), The Calciferous of the Mohawk Valley, (Bull. Pal. Vol. 3, No. 13,) p. 17, figs. 10–13.

4) E. BILLINGS (1965), Palaeozoic Fossils Vol. I, (Geol. Surv. Canada,) p. 303, fig. 293.

convexity, number of ribs, and large delthyrium. This is certainly distinct from *Orthothetes*, and other strophomenoids.

Formation and locality:—Dark reddish fine sandstone; Cerro Pocotaica, near Capinota, Bolivia.

Orthis otaviensis, new species

Plate I, figures 25–27

Description:—Shell relatively large, subtrapezoidal, rounded except at hinge margin, which in turn is straight and represents maximum breadth; ventral valve slightly more convex than dorsal. Notothyrium small and open; cardinal process and median ridge strong; brachiophore small, but distinct.

None of the specimens show the interior of the ventral valve clearly; the muscular scars are well marked, but the anterior ones are obscure. Except at the smooth posterior margin, the surface is marked by about twenty simple ribs.

Formation and locality:—Greenish and yellowish sandstone; west of Otavi, Bolivia.

Genus DIORTHIS Hall and Clarke, 1892

Diorthis obispoensis, new species

Plate I, figures 22–24

Description:—Small orthid, semi-circular in outline, ornamented by 22 or 23 simple ribs. Ventral valve frequently convex in umbonal half, and its cardinal nearly flat; dorsal valve very slightly convex. Delthyrium and notothyrium open, in the latter of which narrow, but distinct cardinal process observed. Muscular scars and median ridge in dorsal valve not strongly impressed.

Comparisons:—*D. pectinella* (Emmons)[1] has more dense radials. This is distinct from *D. proavita* (Winchell and Schuchert)[2] in the greater density of the radials and in the profile of the valves.

Formation and locality:—Black "Knollenschiefer" of Obispo and Puncta Arce.

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1) N. E. Winchell and C. Schuchert (1893), The Lower Silurian Brachiopoda of Minnesota, (Geol. Minnesota Vol. 3,) p. 431, pl. 32, figs. 51–57.

2) Winchell and Schuchert (1893), Op. cit., p. 424, pl 32, figs. 31–34.

Family Orthidae ?

Genus RIOGRANDELLA, new genus

Diagnosis:—Shell subcircular, biconvex, multicostate; internal structure similar to orthids and eoorthids.

Further observations of the genus are given in the description of the genotype.

Genotype:—*Riograndella subcircus*, new species.

Riograndella subcircus, new species

Plate I. figures 15–18

Description:—Shell subcircular, biconvex; ventral valve slightly more convex than dorsal, which in turn is shallowly sulcated in the middle; commissure nearly straight; hinge straight, shorter than maximum breadth of shell; its extremities obtuse; beak small, interareas probably orthocline; surface marked by innumerable fine ribs increasing by bifurcation.

Internally, ventral valve with deep delthyrial cavity, its floor subelliptical; musculatures faintly impressed; dental plates subparallel, little developed; subreniformed ovarian impressions sometimes well marked.

In dorsal valve, notothyrial cavity rather shallow; crura small; dental socket moderately deep; cardinal process distinct; adductor and didductor scars strongly impressed on both sides of median ridge.

Comparisons:—In its external view, this species is quite similar to *Finkelnburgia samensis*, namely in outline, convexity, and surface marking, but its internal characteristics are quite different and is more allied to eoorthids and orthids. Compared with *Eoorthis*, the adductor and diductor scars in this species, though small, are strongly impressed. In regard to the scars this species is allied to *Bohemiella*, but in the latter genus the vascular sinus is quite developed, and further, the latter genus as well as *Oligomys* are distinguished by the character of the deltidial cavity. The Eoorthidae has usually a rather semicircular outline with a long hinge margin.

Were the biconvex profile of the valves, the subcircular outline, and the multicostate surface combined, any genus of Orthidae would have such a form in its fold. Since I could not find any genus to

which I could safely refer it, I have establish a new genus for this species.

Formation and locality:—Sandstone boulder of the Rio Grande, near Ciudod, Bolivia. The slabs in hand contain this species alone, hence geological age indeterminable.

Family Dalmanellidae SCHUCHERT

Genus DALMANELLA HALL and CLARKE, 1892

Dalmanella (?) sp.

Plate I, figures 28

1912. *Orthis* cfr. *edgelliana* HOEK, Op. cit., p. 248.

This is represented by a dorsal (?) valve and conferred to *Orthis edgelliana* SALTER[1] of the Upper Wenlock of England, which in turn is referred to *Idiorthis* McLEARN by SCHUCHERT and COOPER[2] with some doubt.

Even its external view, which is quite clear to the observer, shows some differences from the British one. KOZLOWSKI[3] suggests that this, together with *Orthis* cfr. *emacerata*, might belong to the *Dalmanella* group. This view may be justified.

Formation and locality:—Green shale; Totorapampa.

Dalmanella (?) sp.

Plate I, figure 29

1912. *Orthis* cfr. *emacerata* HOEK, Op. cit., p. 284.

This is represented by an external mould of a ventral (?) valve smaller than the preceding. I can find no objection to this being recognized as belonging to an identical species, and that it is another valve in a younger stage.

Formation and locality:—Same as the preceding.

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1) T. DAVIDSON (1864–1871), British Fossil Brachiopoda, Vol. III, (Palaeontologr. Soc.), p. 225, Pl. XXXII, figs. 1–4.

2) SCHUCHERT & COOPER (1932), Brachiopod Genera of the Suborders Orthoidea and Pentameroidea, p. 128.

3) KOZLOWSKI (1930), Op. cit., p. 333

Phyllum MOLLUSCA

Class GASTROPODA

Family Bellerophontidae McCoy

Genus BUCANIA Hall, 1847

Bucania mudanensis, new species

Plate I, figure 30

This specimen, found on a slab of Kayser's material, reminded me at a glance of *Oxydiscus keideli*, both agreeing with each other in the mode of coiling, deep and narrow open umbilicus, and fine striae. They are, however, readily distinguished by the section of whorl, slit-band, and other characteristics. The section is quite wide, widest at the middle of the outer half, and a distinct concave slit-band is observable, marked by an elevated ridge on each side. The last feature suggests that this species belongs to the Fissidorsata group of Reed.[1] The surface ornament is somewhat cancellated; a strong subequidistant growth-ridge meets the slit-band at about 60°; the space between the ridges is crossed by lines subrectangular to the ridges.

So far as the above observations are concerned, this species certainly belongs to *Bucania* and is well characterized by its broad slit-band defined by elevated ridges and surface ornaments.

Formation and locality:—Sandstone of Mudana, South of Humahuaca, Jujuy.

Family Euomphalidae de Koninck

Genus PELAGIELLA Matthew, 1895

1895. *Pelagiella* Matthew, The *Protolenus* Fauna, (Trans. New York Acad. Sci. XIV,) p. 131.

1997. *Pelagiella* Miller, N. A. Geol. Pal. 2d. ed. App. p. 769.

1909. *Pelagiella* Grabau and Shimer, N. A. Index. Fossils, 1, p. 823.

Genotype:—*Cryptolites atlantoides* Matthew.

Remarks:—Since Matthew[2] established this genus out of

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1) F. R. Cowper Reed (1918), A Monograph of the British Ordovician and Silurian Bellerophontacea, (Palaeontogr. Soc.), p. 2,

2) G. F. Matthew (1894), Trans. Royal Soc. Canada, Vol. XI, Sec. IV, p. 94, pl. XVI, figs. 8a–b.

Cryptolites atlantoides MATTHEW[1] from the *Protolenus* bed of New Brunswick, several species of *Platyceras* known from the Upper Cambrian of New York[2] and of the Middle and Upper Cambrian of China[3] have been transferred to this genus, a few species of mine[4] from Manchoukuo and Chosen have been added. They are listed below.

Middle Cambrian of North China
Pelagiella chronus (WALCOTT)
Pelagiella willisi (WALCOTT)
Late Middle Cambrian of South Chosen
Pelagiella (?) *reversa* KOBAYASHI
Upper Cambrian of North China
Pelagiella clytia (WALCOTT)
Pelagiella pagoda (WALCOTT)
Upper Cambrian of Manchoukuo
Pelagiella hinomotoensis KOBAYASHI
Upper Cambrian of South Chosen
Pelagiella hana KOBAYASHI
Upper Cambrian of New York
Pelagiella hoyti (WALCOTT)
Pelagiella minutissima (WALCOTT)

These specific distinctions are based on the mode of coiling, section of the whorl, and surface features. A concave band is seen along the apertural margin in *P. atlantoides*, and all around the periphery of the shell in *P. minutissima*. In *P. chronus* a narrow sharp ridge runs along the middle of the lateral side of the whorl. The longitudinal striae are tolerably well marked in *P. minutissima*.

Platyceras primarvum BILLINGS from the Middle Cambrian of New York and eastern Canada may be a *Pelagiella*, since WALCOTT[5] says

1) G. F. MATTHEW (1895), The *Protolenus* Fauna, (Trans. N. Y. Acad. Sci. XIV,) p. 131.

2) C. D. WALCOTT (1912), New York Potsdam-Hoyt Fauna, (Smiths. Misc. Coll. Vol. 57, No. 9, p. 254.)

3) C. D. WALCOTT. (1913), The Cambrian Faunas of China, (Research in China Vol. 3.)

4) T. KOBAYASHI (1933), Upper Cambrian of the Wuhutsui Basin, Liaotung with Special Reference to the Limit of the Chaumitian (or Upper Cambrian) of Eastern Asia, and its Subdivision, (Japan. Jour. Geol. Geogr. Vol. XI.)

T. KOBAYASHI (1935), The Cambro-Ordovician Formations and Faunas of South Chosen, Palaeontology, Pt. III, Cambrian Faunas of South Chosen, etc., (Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. II, Vol. IV, Pt. 2.)

5) C. D. WALCOTT (1886), Second Contribution to the Studies on the Cambrian Faunas of North America, (U. S. Geol. Surv. Bull. 30,) p. 130.

that "the inner whorl is scarcely elevated above the outer." The occurrence of the species in the Lower Cambrian of Hartshill, England, has been reported by COBBOLD.[1)]

Cryptolites is coiling in one plane and *Platyceras* has a high spire irregularly coiled. These features distinguish *Pelagiella* from *Cryptolites* and *Platyceras*. Furthermore the spire in this genus is sunken or, at any rate, not elevated. With the accumulation of further material and a thorough revision, these species of *Pelagiella* may have to be split into several genera or subgenera, but they will nevertheless have the above mentioned common characteristics.

This species of the genus was once compared to *Atlanta* in the Heteropoda by MATTHEW, who inferred its free swimming habit, like *Atlanta*, from the presence of the concave band on the periphery.

Pelagiella escayachensis, new species

Plate I, figures 31-32, (?) 33.

As just mentioned, *Pelagiella* has been confined to the Cambrian of Eastern Asia, Europe, and North America. When studying the *Kainella* fauna from Argentina, I saw an incomplete specimen of *Pelagiella* from a coarse-grained sandstone of Prairie Catamarca, Hence this is the second time I have seen a South American representative of the genus.

This form from Escayache has about three volutions, rapidly expanding and coiled almost in one plane; the section of the whorl is sublenticular; the inner slope is much steeper than the outer, which in turn, is rather concave near the periphery. The ratio of length between the shell and the last whorl is about 5 : 3. The surface feature is unknown.

The Catamarca specimen resembling this species has a fine peripheral keel and weak longitudinal striae. Neither concave marginal band, nor spiral lateral ridge is actually to be seen on either specimen.

This species is most closely related to *Pelagiella hana*, from which it is distinguished by its gentle coiling and fine peripheral keel.

Formation and locality:—Late Upper Cambrian light green sand-

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1) E. S. COBBOLD (1919), Cambrian Hyolithidae etc. from Hartshill in the Nuneation District, Warwickshire, (Geol. Mag. New Ser. Dec. VI, 6,) p. 155, pl. IV, fig. 34.

stone of the western wing of Escayache. The exact locality and horizon of the other specimen is unknown, but must have come from somewhere in Preirie Catamarca.

Class PELECYPODA Goldfuss

Family Ctenodontidae Dall

Genus CTENODONTA Salter, 1851

Ctenodonta cochabambensis, new species

Plate I, figures 34–36

1912. *Nucula* sp. Hoek, Op. cit., p. 241, pl. XI, fig. 5.

Description:—Shell subovate and gently convex; antero-lateral margin straight; anterior adductor scar quite strong, located at short distance from frontal extremity; posterior adductor scar weak, close to posterior end; teeth numerous, geniculated toward beak; approximately 12 denticles anterior to beak, more than 25 posterior to it; no resilium-pit; surface smooth except for lines of growth.

Comparisons:—This belongs to the *Ctenodonta recurva* section of Ulrich.[1] His five species of this section have, however, more triangularly ovate outlines. In outline alone it resembles *Ctenodonta symmetrica* Grabau[2] and *C. subsymmetrica* Kobayashi,[3] but in *C. symmetrica* the beak is more prominent and both sides of the beak are almost symmetrical, as so named; in *C. subsymmetrica*, on the other hand, the beak is less prominent than that of this species, and a narrow area below the beak is elevated to an extraordinary degree.

Ctenodonta takahashii Endo, *C. manchuriensis* Endo,[4] and *C. shanensis* Reed[5] are also similar, but *C. takahashii* has a blunt posterior

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1) E. O. Ulrich (1897), Lower Silurian Lamellibranchiata of Minnesota, (Geology of Minnesota, Vol. III, Pt. II,) p. 603, pl. 42, figs. 98-101.

2) A. W. Grabau (1922), Ordovician Fossils of North China, (Palaeont. Sinica, Ser. B, Vol. I, Fasc. I,) p. 19, pl. I, fig. 7.

3) T. Kobayashi (1935), The Cambro-Ordovician Formations and Faunas of South Chosen, Palaeontology, Pt. I, Middle Ordovician Faunas, (Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. II, Vol. III, Pt. 8.)

4) R. Endo (1935), Additional Fossils from the Canadian and Ordovician Rocks of Southern Part of Manchoukuo, (Sci. Rep. Tohoku Imp. Univ. Sec. Ser. (Geology) Vol. XVI, No. 4,) pp. 196–197, pl. XV, figs. 1–8.

5) F. R. Cowper Reed (1915), Supplementary Memoir of New Ordovician and Silurian Fossils from the Northern Shan States, (Palaeont. Indica, New Ser. Vol. VI, No. 1,) p. 16, pl. III, figs. 10–12.

keel marking off a narrow triangular frontal area, fine elevated concentric ribs, and outwardly geniculated teeth whose posterior series are composed of only about 10 denticles. The outline of the shell is higher in *C. manchuriensis* than in this species. *C. shanensis* has a wider outline and less prominent beak than this species.

Formation and locality:—White hard sandstone, south of Cochabamba, Bolivia. A slab of this sandstone contains a number of *C. cochabambensis,* in addition to a few indeterminable fragments of shell.

Ctenodonta iclensis, new species

Plate II, figures 12–15

Description:—Shell gently convex, semi-circular in anterior half, subtriangular in posterior; umbo located at point about one-third from anterior to posterior; anterior adductor impression found close to anterior extremity; posterior one slightly behind middle point between umbo and posterior extremity; teeth straight or more or less geniculated toward beak; surface smooth except for lines of growth.

Comparison:—The outline of the shell is variable to some extent. This species is most closely related to *Ctenodonta longa* ULRICH,[1] but is distinguished from it by its outline. The height of the shell is less than twice the length in this species, whereas it is more than twice the length in *Ctenodonta longa* ULRICH. *C. oblongata* KOBAYASHI[2] is another similar form, which differs from *C. iclensis* in the broad outline and faint adductor scar.

Formation and locality:—Dark green medium grained sandstone; Cuesta de Icla. A left valve probably belonging to this species was found also in a slab of *Leiostegina* sandstone of Otavi.

Rock facies:—The sandstone of Cuesta de Icla when viewed laterally shows false bedding. The valves are detached and entombed in the rock mostly with the convex side above. Beside *C. iclensis,* the slab contains quite a few lingulid fragments and detached carapaces of *Leiostegina otaviensis.* Appearances indicate that this sandstone is probably a *Ctenodonta* bank contemporaneous with the *Leiostegina* sandstone of Otavi, which latter contains various fossils. The bank was probably a shallow water deposit, such as a delta,

1) E. O. ULRICH (1897), Op. cit., p. 590, pl. XXXVII, figs. 30–31.
2) T. KOBAYASHI (1934), Op. cit., p. 350, pl. 3, fig. 21, pl. 4, fig. 21.

where the currents and waves were tolerably strong.

Ctenodonta iclensis KOBAYASHI var. *augusta*, new variety

Plate II, figure 16

This variety differs from the preceding one by its higher outline and stronger muscular scar.

Formation and locality:—Dark green medium grained sandstone; Cuesta de Icla.

Ctenodonta mesambonata, new species

Plate II, figure 17

Description:—Shell subellipticall, subequilateral, and gently convex; beak subcentral; more than 20 denticles counted, geniculated inward, of which about two-thirds are behind the beak; adductor scar obscure.

Comparisons:—This species is distinguished from *Ctenodonta iclensis angusta* by its subtriangular posterior outline and strong posterior adductor scar of the latter.

Formation and locality:—A boulder of dark green fine-grained micaceous sandstone, west of Otavi. This species is found associated with *Goniophorina otaviensis.*

Ctenodonta grailis (HOEK)

Plate II, figure 10

1912. *Arca gracilis* HOEK, Op. cit., p. 248, pl. VIII, fig. 17.

Description:—Shell subtrapezoidal and moderately convex; anterior margin semi-circular; hinge margin broadly arcuated; margin in front of beak almost straight and obtusely angulated at its extremity; posterior margin oblique; basal margin nearly straight. Umbo large, projected beyond the hinge margin, slightly incurved; umbonal plication rather acute, roof-shaped and marking off a subtriangular area behind it; area inclined and sometimes concave. Plication increases its prominence in adult stage and at the same time a shallow but wide mesial sinus appears. No radial ribs; except for sinus concentric markings feeble. Under a high magnifying lens, longitudinal lines seen to cross concentrics so as to form fine mesh. Shell thin.

Comparison:—At a glance I was impressed by the resemblance of

this species to *Goniophora*, but the taxodont teeth discriminate this form from *Goniophora*. Such an *Arca*-like outline is quite rare in *Ctenodonta*, but there is one among them, *Ctenodonta carinata* ULRICH,[1] in which however, the umbonal plication is not so sharp as in this species.

Formation and locality:—Yellowish white micaceous shale of Totorapampa, Bolivia.

Ctenodonta aff. *alta* HALL

Plate II, figure 11

1894. aff. *Ctenodonta alta* ULRICH, Op. cit., p. 602, pl. 42, figs. 93, 94.

This is a small shell, subtriangularly ovate in outline, and gently convex. The umbo is central, not elevated. The distinct keel running along the posterior margin is probably due to a secondary deformation. The teeth are geniculated outwardly. More than ten denticles are to be counted in the anterior series. The anterior adductor scar is located close to the anterior end of the shell; posterior scar indistinct. Under high magnification, fine concentric and radial lines are seen on the surface crossing one another in a mesh-like striation. This is quite similar to *Ctenodonta alta* of the Galena, in central North America, although any specific identity is not warranted.

Formation and locality:—A single valve was found associated with *Ctenodonta gracilis* in a yellowish white micaceous shale of Totorapampa, Bolivia.

Family Leididae ADAMS

Genus CLEIDOPHORUS HALL, 1847

Cleidophorus (?) aff. *consuetus* ULRICH

Plate II, Figure 9

1897. aff. *Cleidophorus consuetus* ULRICH, Op. cit., p. 606, pl. XXXVII, figs. 32–33.

This form is represented by two left valves. The one illustrated is an internal cast on which a vertical anterior clavicle is fairly well impressed. Another one, a fragment of the posterior half, shows concentric markings on the surface.

1) ULRICH (1897), Op. cit., p. 589, pl. 42, figs. 41–43.

Generally speaking, this certainly resembles *Cleidophorus consuetus* ULRICH, although the taxodont teeth cannot be seen on the specimens.

Formation and locality:—Sandstone; west of Otavi, Bolivia.

Family Modiolopsidae FISCHER
Genus GONIOPHORINA ISBERG, 1934

Genotype:—*Goniophorina volvens* ISBERG.

Remarks:—MCLEARN[1] separated *Cosmogoniophora* from *Goniophora* and included the forms with radial striae in the former. After a thorough study, ISBERG[2] distinguished *Goniophorina* from *Goniophora*, and established a subgenus *Cosmogoniophorina* to include that form of *Goniophorina* with radial striae. The main disinction between the *Goniophora* and *Goniophorina* lies in the ligaments, outer in the former and inner in the latter. The South American collection contains more than three species of *Goniophora* (s. l.), all having concentric marking only, but none of which clearly show the external ligaments, hence they are referred to *Goniophorina*.

Goniophorina tambillosensis, new species

Plate II, figures 20–21

This is represented by a single left valve, tolerably convex, and wide, and has practically no distinct median sinuation. A keel runs from the umbo to the postero-lateral end. This keel is not very sharp, but gradually increases its prominence backward. The posterior area is relatively long and gently waving; the surface is marked by blunt concentric foldings.

Formation and locality:—Greenish hard medium grained sandstone; west of Tambillos. Indeterminable fragments of trilobites are found in the slab.

Goniophorina isbergi, new species

Plate II, figures 18–19

Description:—Shell equivalve, strongly convex and without median

1) F. H. MCLEARN (1914), Palaeontology of the Silurian Rocks of Arisaig, Nova Scotia, (Geol. Surv. Canada, Mem. 137,) p. 132.

2) O. ISBERG (1934), Studien über Lamellibranchiaten des *Leptaena*-kalks in Dalarna, pp. 202–205.

sinus; rounded posterior keel obtuse and diagonal, marking off posterior area which in turn is rather concave and crossed by a transverse ridge along middle of area; concentric markings indistinct.

Observation:—One right and four left valves of this species were found on a slab of sandstone west of Otavi. In other boulder collected west of Otavi were found right and left valves, both much smaller than those just described. They, however, certainly belong to the same species. The external casts show rather distinct concentric lines of growth. The diagonal keel is quite strong in the internal cast. A faint groove is, moreover, found along the hinge margin posterior to the beak, which is probably an impression of the internal ligament.

Comparison:—Compared with *G. tambillosensis*, this species is more convex and narrower, its anterior margin more abruptly rounded, and the umbonal ridge more obtuse.

Formation and locality:—Light green to white massive sandstone; west of Otavi, Bolivina. Beside this species, *Cleidophorus* (?) aff. *consuetus*, a species of indeterminable pelecypods resembling *Ctenodonta mesambonata* in outline, and some detached thoracic segments of trilobites are found on the slab. All the pelecypod shells are found with their concave sides up. In a boulder west of Otavi are found a mass of pelecypods including *G. otaviensis* and *Ctenodonta mesambonata*, besides a few fragments of lingulids and *Leiostegina*.

Goniophorina (?) *otaviensis*, new species

Plate II, figure 26

Internal moulds of right and left valves in hand. In outline and size this species is quite allied to *Ctenodonta gracilis*, although the internal structure is quite distinct. This species has a long, rudimentary postero-lateral tooth, which is a linear thickening along the hinge margin. The adductor scars and the pallial line cannot be seen; an umbonal plication is strongly developed. A shallow but wide mesial sinus is present in front of the plication.

Formation and locality:—Boulder of dark green, fine-grained, somewhat conglomeratic and micaceous sandstone, west of Otavi.

Class CEPHALOPODA Kopffüsser
Subclass TETRABRANCHIATA Owen
Order NAUTILOIDEA Zittel
Family Endoceratidae Hyatt
Genus ENDOCERAS Hall, 1844

"*Endoceras*" *a* sp.

Plate VII, figures 10a–c

1912. *Endoceras* sp. Hoek, Op. cit., p. 233, pl. XIII, fig. 1.

The specimen in hand consists of an incomplete body chamber and phragmacone slowly tapering; in cross section it is subovate, dorso-ventrally depressed, and distinctly flattened on the venter (fig. 10a); siphuncle nearly as wide as two-fifths the dorso-ventral diameter of the conch and actually in contact with the shell on the ventral point (fig. 10c); septum ascending rather steeply; from the siphonal to the antisiphonal side; siphuncle filled with dirt; shell thick.

Formation and locality:—Hoek states that the specimen was collected from San Lucas, N. Camergo, but the label attached to the specimen reads "Knollenschiefer" of Sivingomayo. The matrix attached to the shell and filling the body chamber is a compact shale.

"*Endoceras*" *b* sp.

Plate III, figures 22–24

1912. *Endoceras* sp. Hoek, Op. cit., p. 236, (listed.)

Siphuncle cylindrical; its cross section circular at apical end and subovate, slightly wider than long, and more or less flattened on ventral (?) side; septa crowded; eight septal sutures and seven intervals counted in distance equial to dorso-ventral diameter; septal sutures ascending from venter to dorsum about three times camera-height and running all around siphuncle.

Surface features of siphuncle suggest that septal funnel is invaginated within the preceding and concave between septal necks.

Formation and locality:—Sandy shale of Sucre. Three siphuncles from Sucre certainly belong to an identical species, on one of which the locality is given in Steinmann's handwriting as being a few miles west, instead of east, of Sucre.

"*Endoceras*" c sp.

Plate II, figure 22

Siphuncle tapering slowly, depressed dorso-ventrally and flattened on venter, but complete cross section unknown, because dorsal part not preserved. Septal sutures crowded and traverse the ventral flattening. Since surface of siphuncle is not annulated as in preceding; septal funnel believed to be nearly straight and subparallel to axis of siphuncle.

Formation and locality:—Sandstone (?) of S. Lucas.

Family Cycloceratidae Hyatt

Genus CYCLOCERAS M'Coy, 1844

Cycloceras grecicostatum, new species

Plate VIII, figures 4a–c

Description:—Cyrtoceracone slightly curved, gradually expanding, circular in cross section; annulation very slender, ascending from concave to convex side; about five annulations and intervals distributed in distance equal to shell-diameter; fine straight lines parallel to annuli cover surface of shell; siphuncle tubular, excentric, slightly narrower than one-fourth diameter of shell and occupying second quarter from concave margin, three and a half camerae distributed in distance equal to diameter of shell; septal depth slightly less than camera-height; siphuncle and camera filled with dirt and secondary calcareous deposit.

Observation:—The anterior half of the specimen is secondarily crushed by compression in the dorso-ventral direction, and the cross section of the conch has an elliptical outline as illustrated in fig. 4c. The annulations and lines, which are not distinct in the earlier stage, become more distinct later.

Formation and locality:—" Knollenschiefer " of Obispo.

Family Sactoceratidae Troedsson

Genus ORMOCERAS Stokes, 1838

Ormoceras bolivianum (Hoek)

Plate II, figures 23–24

1912. *Orthoceras bolivianum* Hoek, Op. cit., p. 299

Description:—Shell smooth, tapering at rate of 1 mm. in 10 mm.

or so, subcircular in cross section; siphuncle subcentral; each segment between septal necks fusiformed, higher than broad, very slowly increasing its breadth with reference to growth of shell; diameter at swelling point corresponding to about one-third diameter of conch where it is 7 mm. across, but one-fifth diameter of conch where it is 17 mm.; camera also increases its altitude slowly; septal convexity nearly uniform; septal depth ranges from one and half to half camera-height from apical side to another; stereoplasmic deposit accumulated on lower and outer walls of camera; small rosetti seen in apical portion of siphuncle.

Observation:—The original specimen described by HOEK was collected at Quechisla, west of Cotagaita by BOCK and contained in the collection. This cephalopod is imbedded in the arenaceous rock, and the stereoplasmic deposits in the camera and siphuncle are not well developed. The specimens are deformed secondarily in various degrees, and the cross section of the conch sometimes reveals a subelliptical outline. The original outline was presumably subcircular.

Observations on the septal neck and its bearing on the phylogeny:— In the sections of three specimens there is observed a variation in the septal neck, i. e. in the feature of the hook at the septal neck, which is very sharply bent at some points and rather broadly at others. In a few instances the septum adnates with the connecting ring directly, and no distinct hook can be seen at the neck. Such a variation from the *Actinoceras* type to the *Thuloceras* type happens irregularly, and not in accordance with the stage of growth.

Thus, septal nature is not a concrete character even in one individual. This in turn raises the question how far one can rely upon such a character for classificatory purposes. With TEICHERT, I am of the opinion, as I have already emphasized, that the general organization and the stereoplasmic deposit are much more important for the purpose.

Another important fact is that the shell structure grows from the *Sactorthoceras* stage to the *Ormoceras* stage through the *Stereoplasmoceras* stage; in other words, in the anterior portion, the phragmacone has no stereoplasmic deposit, but later the stereoplasma is deposited in the camera, after which the rosetti is formed at the septal neck. Therefore, contrary to TEICHERT, I repeat my previous conclusion that the actinoceroid is derived from the orthoceroid, probably from near *Sactorthoceras*. Judging from this species only,

it would appear more likely, however, that the evolutional line developed through *Stereoplasmoceras*, instead of through *Sactoceras*, because in the ontogeny of *Ormoceras bolivianum* the intracameral stereoplasmic deposit begins to accumulate prior to the rosetti.

Comparison with other species of Ormoceras:—The distinguishing specific characteristics are the subcentral siphuncle, relatively high siphuncular segment; small rosetti; and stereoplasmic intracameral deposit limited to the posterior and external sides of the camera. The growth of the rosetti is quite retarded in this species. In *Ormoceras hayfieldi* and most other species of *Ormoceras*, the rosetti is usually much larger, which however, is only a difference in degree, so that if it is used in classification, one will meet with every intermediate step in the size of rosetti. Therefore, until further distinctions can be made, I refer this species to *Ormoceras*.

Formation and locality:—Sandstone of Quechisla, near Uyuni, Bolivia.

Phylum ARTHROPODA

Class CRUSTACEA

Order TRILOBITA Walch

Suborder Agnostida Kobayashi

Agnostus used to be a very comprehensive generic name for trilobites consisting of a semi-circular cephalon and pygidium in addition to two thoracic segments, but now most specialists point out that the variations it comprises are too extensive for one genus in the modern sense.

As early as 1847 Corda[1] attempted to split the agnostidian group into several genera. Subsequently, in 1880, Tullberg[2] divided *Agnostus* (s. l.) into four sections with two subsections for the Limbati section, which has long been accepted by Matthew,[3]

1) I. Hawle and A. J. Corda (1847), Prodrome einer Monographie der böhmischen Trilobiten.

2) S. A. Tullberg (1880), Om *Agnostus*-Arterna i de Cambriska Aflagrigarne vid Andrarum, (Sver. Geol. Unders. Ser. C, Nr. 42.)

3) G. F. Matthew (1896), Fauna of the *Paradoxides*-Beds in Eastern North America, No. 1, (Trans. N. Y. Acad. Sci. Vol. XV.)

GRÖNWALL,[1] LAKE,[2] ILLING[3] and most other palaeontologists. In modifying TULLBERG's classification, JAEKEL,[4] in 1909, distinguished four families. Since, however, he ignored the generic names already established by CORDA, RAYMOND[5] straightened out the nomenclature and subsequently recognized the four divisions placing them in a subfamily rank.[6] A brief account of this matter was given in my South Korean memoir.[7]

Acurate revisions of the Agnostidian classifications have been repeated in recent years and various opinions expressed by HOWELL,[8] WHITEHOUSE,[9] and WESTERGÅRD,[10] but the classifications have not as yet been set on the stable ground. The following discussions deal with smooth agnostids, Pseudagnostidae, Geragnostidae, and concerned species genera and families.

On the Smooth Agnostids

As in the case of non-agnostidian trilobites, the most difficult task is to trace the phylogenetical relationship among the smooth agnostids, namely Laevigati of TULLBERG, Phalacromides of CORDA, or Phalacrominae of RAYMOND, because obliteration of surface markings has left only a few characteristics to judge from. In some

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1) K. A. GRÖNWALL (1902), Bornholm *Paradoxides*-lag og deres Fauna, (Danmarks Geologiske Undersogelse, II Raekke, Nr. 13.)

2) P. LAKE (1906), A Monograph of the British Cambrian Trilobites, Part I, (Palaeontogr. Soc.)

3) V. C. ILLING (1915), The Paradoxidian Fauna of a Part of the Stockingford Shale, (Quart. Jour. Geol. Soc. London, Vol. LXXI.)

4) O. JAEKEL (1909), Über die Agnostiden, (Zeitschr. deutsch. geol. Gesell. Bd. 61.)

5) P. E. RAYMOND (1913), Some Changes in Names of Genera of Trilobites, (Ottawa Naturalist, Vol. XXVI.)

6) P. E. RAYMOND (1913), in ZITTEL-EASTMAN's Text-Book of Palaeontology, Vol. I.

7) T. KOBAYASHI (1935a), The Cambro-Ordovician Formations and Faunas of South Chosen, Palaeontology, Part III, Cambrian Faunas of South Chosen with a special Study on the Cambrian Trilobite Genera and Families, (Jour. Fac. Sci. Imp. Univ. Tokyo Sect. II, Vol. IV, Pt. 2.)

8) B. F. HOWELL (1935a), Some New Brunswick Cambrian *Agnostus*, (Bull. Wagner Free Inst. Sci. 10, No. 2.)

B. F. HOWELL (1935b) New Middle Cambrian Agnostian Trilobites from Vermont, (Jour. Pal. Vol. 9.)

B. F. HOWELL (1935c) Cambrian and Ordovician Trilobites from Herault, Southern France, (Jour. Pal. Vol. 9.)

9) F. W. WHITEHOUSE (1936), The Cambrian Faunas of Northeastern Australia, (Mem. Queensland Mus. Vol. XI.)

10) A. H. WESTERGÅRD (1936), *Paradoxides oelandicus* Beds of Öland, etc., (Sverig. Geol. Unders. Ser. C, Nio 394.)

instances, the question is which is the head and which the tail.

Of the smooth agnostids, HOWELL[1] distinguished three evolutional branches, namely, the Phalacromidae, Platagnostidae, and Leiagnostidae. The first family comprises *Phalacroma, Grandagnostus* and *Gallagnostus*; the second and third are represented by each genus named after it. The first family is confined to Middle Cambrian and the third to Lower Ordovician, but the second ranges from late Middle to Upper Cambrian.

WHITEHOUSE,[2] on the contrary, pointed out that HOWELL'S *Grandagnostus* and *Gallagnostus* are synonyms of *Phalacroma*. In addling two new genera, *Cotalagnostus* and *Phoidagnostus*, he intended for the time being to group all the smooth agnostidian genera in the Phalacromidae, for the reason that the polyphyletic origin of the smooth agnostids has not as yet been positively substantiated.

So far as I am aware, the following 10 genera have been established as smooth agnostids, their type species being given in brackets:—

Phalacroma CORDA, 1847 (*Agnostus nudus* BEYRICH)
Lejopyge CORDA, 1847 (*Agnostus laevigatus* DALMAN)
Miagnostus JAEKEL, 1909 (*Agnostus laevigatus* ANGELIN)
Leiagnostus JAEKEL, 1909 (*Agnostus erraticus* JAEKEL)
Grandagnostus HOWELL, 1935 (*Grandagnostus vermontensis* HOWELL)
Gallagnostus HOWELL, 1935 (*Gallagnostus geminus* HOWELL)
Platagnostus HOWELL, 1935 (*Agnostus bibullatus* BARRANDE)
Cotalagnostus WHITEHOUSE 1936 (*Agnostus lens* GRÖNWALL)
Phoidagnostus WHITEHOUSE, 1936 (*Phoidagnostus limbatus* WHITEHOUSE)
Spaeragnostus HOWELL and RESSER,[3] 1936 (*Agnostus similaris* BARRANDE)

Since, of these, *Miagnostus* is a synonym of *Lejopyge*, owing to duplication of the type species, it can be excluded from the discussion.

To read through the story of the evolution of the smooth agnostid, the first essential is the restoration of the fundamental

1) HOWELL (1935b, c), Op. cit.
2) WHITEHOUSE (1936), Op. cit., p. 92.
3) B. F. HOWELL and C. E. RESSER (1936), in A. G. COOPER and C. H. KINDLE'S New Brachiopods and Trilobites from the Upper Ordovician of Percé, Quebéc, (Jour. of Pal. vol. 10,) p. 361.

configuration of shield, which existed before obsoletion of the surface relief advanced, and for which purpose the outline and convexity of the carapace, breadth of the axis, and the presence or the absence of the marginal brim should be carefully examined. As noticed on some occassions,[1] the structure is frequently well-impressed under the test, even when the dorsal surface is entirely smooth. Obsoletion in the trilobite is usually less advanced in the pygidium than in the cephalon, hence it is advisable to start with an examination of the pygidium. The attempt should be successful in many cases, when the original aspect of the lobation can then be figured out.

The tracing from the smooth form into one in relief has already been initiated by WHITEHOUSE.[2] He suggested that *Cotalagnostus altus* (GRÖNWALL) is united to *C. frontosa* (GRÖNWALL) probably through *C. lens* (GRÖNWALL). The time relation agrees with this morphological array, because *altus* occurs in the *davidis* zone, whereas *lens* as well as *frontosa*, occur in the *tessini* zone.[3]

He moreover referred *Agnostus barrandei* SALTER and *A. kushanensis* WALCOTT to this genus. According to ILLING,[4] the former species ranges from the top of the *hicksi* zone to the lower part of the *davidis* zone. The latter occurs in the Kushan, namely, the top of the Middle Cambrian of Eastern Asia. *C.* aff. *kushanensis* appears, however, in Queensland in the *Dinesus* zone, which is approximately equated to the *Ctenocephalus exsulans* zone.

The breadth of the axial lobe and medium-sized brim of the cephalon, as well as the pygidium, suggest that *Cotalagnostus* may be an offshoot from the stock of the normal agnostid, or the Agnostidae inclusive of the Spinagnostidae of HOWELL.[5] As noticed by GRÖNWALL[6], *C. lens* is closely allied to *Agnostus laevigatus*, but in the carapace, especially in the pygidium, of the latter species, the lobation is more obscured.

Laevigatus is a type species of *Lejopyge*, namely, *Miagnostus*, to which in turn *Agnostus cicer* TULLBERG was referred to by JAEKEL.[7] WHITEHOUSE[8], on the other hand, referred *Agnostus confusus* HOLM

1) KOBAYASHI (1935a), Op. cit., p. 303
2) WHITEHOUSE (1936), Op. cit., p. 93.
3) GRÖNWALL (1902), Op. cit., p. 167.
4) ILLING (1915), Op. cit., p. 413.
5) HOWELL (1935b), Op. cit., p. 218.
6) GRÖNWALL (1902), Op. cit., p. 210.
7) JAEKEL (1901), Op. cit., p. 401.
8) WHITEHOUSE (1936), Op. cit., p. 97.

and WESTERGÅRD,[1] *Microdiscus lenaicus* VON TOLL,[2] and *Agnostus barlowi* BELT and *Lejopyge exilis* WHITEHOUSE to this genus. BELT's species of 1868 was identified with TULLBERG's *cicer*, in 1880, by LAKE,[3] and a variety, *spicatus*, a form with tiny spines on the pygidium, was added to the species by ILLING.[4] On account of the wide axial lobe of its pygidium *barlowi*, i. e. *cicer*, is, however, quite distinct from other species of *Lejopyge*.

The *Agnostus laevigatus* zone marks the top of the Middle Cambrian strata in the Atlantic province. *Lejopyge confusus* is denominated to *Agnostus bituberculatus* BRÖGGER,[5] non ANGELIN, which is known to be distributed in the *forchhammeri* zone in Scania, Sweden, Krekling, Norway, and probably in Bennett Island. *L. exilis* occurs in the *Phoidagnostus* stage of Queensland which approximately corresponds to the *davidis* zone.

Thus, *Lejopyge* dominates in the late Middle Cambrian, while *Cotalagnostus* does in the medieval Middle Cambrian. Since obsoletion of the surface marking is one step more advanced in the former than in the latter, it seems reasonable to believe that *Lejopyge* was derived from *Cotalagnostus*. The two genera may be united by such intermediate forms as *terranovica* and *ciceroides* that occur in the *davidis* zone of Newfoundland.[6] According to WHITEHOUSE, these varieties of MATTHEW are probably closer to *Cotalagnostus* than to *Lejopyge*.

CORDA[7] founded *Phalacroma* for the smooth agnostids with an illustration of *Phalacroma scutiforme*, besides 11 species, including *nudus*, *bibullatum*, and *laevigatum*, which were referred to it. Then he took the cephalon for pygidium. Subsequently BARRANDE,[8] who studied on CORDA's actual specimens, pointed out that *emarginatum*, *carinatum*, *scutiforme*, and *gibbosum* represent various growth-stages

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1) G. HOLM and A. H. WESTERGÅRD (1930), A Middle Cambrian Fauna from Bennett Island, (Mém. de l'Acad. des Sci. de l'URSS, Tom. XXI, No. 8,) p. 12, pl. IV, figs. 7–8.

2) E. VON TOLL (1899), Beiträge zur Kenntnis des sibirischen Cambrium, I, (Mém. de l'Acad. Imp. des Sci. de St.-Pétersbourg, VIIIe Ser. Tom. VIII, No. 10,) p. 23, pl. I, figs. 6–8, 15–16.

3) LAKE (1906), Op. cit., p. 17.

4) ILLING (1915), Op. cit., p. 413, pl. XXX, figs. 11–12.

5) W. C. BRÖGGER (1878), Om *Paradoxides*-skiferne ved Krekling, (Nyt Mag. for Naturv. XXIV, 1,) p. 59, pl. 6, fig. 9.

6) MATTHEW (1896), Op. cit., p. 212.

7) CORDA (1847), Op. cit., pp. 43–45.

8) J. BARRANDE (1852), Systême silurien du Centre de la Bohême, Vol. I, Text, pp. 901–908.

of *nudus*, while *quadrinotatum*, *ellipticum*, and *ovatum* are synonymous with *bibullatus*. Therefore, *Agnostus nudus* BEYRICH, 1845,[1] should stand for the type species of *Phalacroma*.

Agnostus marginata BRÖGGER and *A. scanicus* TULLBERG, and probably *A. ovalis* ILLING, *A. eskriggei* HICKS, and *Phalacroma* ? *dubium* WHITEHOUSE, are also referable to this genus. *Marginatus*, *scanicus*, and even *ovalis*, are so closely related that BRÖGGER, TULLBERG, GRÖNWALL, and ILLING regard them as varities of *nudus*. They have all a median tubercle on the pygidium. *Ovalis*[2] is, however, easily distinguishable from the other three by a wide flange on the pygidium.

Eskriggei[3] is a non-tuberculated form, but it apparently resembles *ovalis*. They are, however, really distinct, because the former has a broad circular axial lobe clearly defined by a deep furrow from the rest of the pygidium which, in turn, looks similar to the flange of the latter, but which in fact, indicates a pleural lobe. Since, as suggested by LAKE,[4] *eskriggei* is allied to the young form of *nudus*, illustrated by BARRANDE,[5] this may be an aberrant form of *Phalacroma*.

The tuberculated *nudus*, *scanicus*, and *marginatus* occur in the *tessini* zone; the peculiar *ovalis* in the *davidis* zone; and the non-tuberculated *dubium* in the *Phoidagnostus* zone. Therefore, *ovalis* and *dubium* might be indicative of a later development of *Phalacroma*.

Phalacroma thorali HOWELL[6] looks more similar to *Gallagnostus* than to *Phalacroma*. HOWELL instituted *Grandagnostus* for *Grandagnostus vermontensis* HOWELL, and referred *Agnostus glandiformis* ANGELIN to it. The generic significance which he pointed out is the extraordinary size of the agnostid, which WHITEHOUSE[7] belives insufficient for generic distinction. *Glandiformis* occurs in the *forchhammeri* zone and *vermontensis* in the *Centropleura* zone. Both have the median tubercle on the pygidium, and reveal a later development of the *Phalacroma* branch.

WHITEHOUSE instituted *Phoidagnostus* with *P. limbatus* WHITE-

1) E. BEYRICH (1845), Ueber einige böhmische Trilobiten, p. 46, fig. 20.
2) ILLING (1915), Op. cit., p. 415, pl. XXXI, figs. 9–10.
3) H. HICKS (1872), On some underscribed Fossils from the Menevian Group of Wales, (Quart. Jour. Geol. Soc. London, Vol. XXVIII,) p. 175, pl. V, fig. 7.
4) LAKE (1906), Op. cit., p. 16.
5) BARRANDE (1852), Op. cit., pl. 49.
6) HOWELL (1935c), Op. cit., p. 227, pl. 22, figs. 19–20.
7) WHITEHOUSE (1936), Op. cit., p. 95.

HOUSE, and referred *Agnostus bituberculatus* ANGELIN, (non BRÖGGER) to it. The former species occurs in the *Phoidagnostus* zone and the latter in the *forchhammeri* zone. Except for the basal accessary lobes of the glabella, which are present in *Phoidagnostus*, *Phalacroma* agrees with *Phoidagnostus* in most details. The latter is less obliterated than the former.

Agnostus barlowi, i. e. *cicer*, is only one step removed from *Phoidagnostus*. In other words, *barlowi* is a *Phoidagnostus* with the axial lobe marked by furrows at a distance from the articulating margin. Based on this characteristic I establish *Ciceragnostus* (nov.) for *Agnostus barlowi* BELT and include *Agnostus spicatus* ILLING in it.

According to LAKE[1], BELT has erroneously recorded the occurrence of his species in the Tremadoc. The former insists that it must have been obtained from the Paradoxidian, because, in Scandinavia *cicer* ranges from the *davidis* to the *aequalis* zone. *Spicatus*, on other hand, was found by ILLING in the middle part of the *hicksi* zone.

Although the extent of obsoletion in the surface relief differs, *Ciceragnostus*, *Phoidagnostus*, and *Phalacroma* are equally characterized by a broad axis. The morphological series involving the three genera may be a parallel in the Paradoxidian to that of *Cotalagnostus-Lejopyge*, which, in its turn, usually has a narrower axis.

Gallagnostus is founded on *Gallagnostus geminus* HOWELL from the mediaeval Middle Cambrian of South France. Judging from the thorax, its axis is quite broad. The species, moreover, is characterized by a similarity in the cephalon and pygidium, which are slightly convex, practically smooth, and bordered by a brim of equal breadth. The median tubercle is absent. The species agrees with *Phalacroma thorali* best of all, but since *thorali* retains a trace of the median tubercle on both shields, *Gallagnostus* may well be placed next to *Phalacroma*, as was done by HOWELL. *Agnostus bolivianus* and *A. iruyensis*, which he referred to this genus, will be discussed in some detail in the succeeding pages.

Plathagnostus is based upon *A. bibullatus*, and *Plathagnostus immensus* has been added to it. The formar species[2] occurs in the

1) LAKE (1906), Op. cit., p. 17.

2) J. F. POMPECKJ (1896), Die Fauna des Cambrium von Tejrovic and Skrej in Böhmen, (Jahrb. der k. k. geol. Reichesans. Bd. 45, Hft. 2–3,) p. 520.

reddish *Paradoxides*-schiefer of Tejrovic and the green *Paradoxides*-schiefer of Skrej, Bohemia, and the latter[1] in the *Conocoryphe levyi* zone of Southern France. They differ in the median tubercle, which, though distinct in the former, is indiscernable in the latter. Both however, are well characterized by their long axes on the pygidia which reach the posterior grooves and are expanded backward. *Plathagnostus* agrees with phalacromids with regard to the wide axial lobe, but the true relation cannot be ascertained until the axial outline of the phalacromid can be figured out.

In summarizing the foregoing discussion, there are in the Middle Cambrian, two distinct branches of smooth agnostids, namely, the *Lejopyge* line and *Phalacroma* line. The former comprises *Cotalagnostus* and *Lejopyge*; the latter *Ciceragnostus, Phoidagnostus. Phalacroma* inclusive of *Grandagnostus,* and probably *Gallagnostus.* The former line was derived most probably from the main stock of the normal agnostids, or of the Agnostidae inclusive of the Spinagnostidae. The latter might also have branched off from the same stock, but after the normal agnostid had aquired a broader axis.

The Plathagnostidae is a small off-shoot that is located closer to the Phalacromidae than to the *Lejopyge* line, but it may be aberrant.

Jaekel established *Leiagnostus* for *Leiagnostus erraticus* and referred *nudus, scanicus,* and *glandiformis* to it. Raymond subsequently synonymized the genus with *Phalacroma,* but recently Howell[2] retained *Leiagnostus,* restricting its use to Ordovician forms, such as *erraticus, bohemicus,* and *foulonensis.* This action, however, was questioned by Whitehouse,[3] who maintained that generic distinctions should be made with reference to morphological characters, not geological distribution.

Obviously, the geological and geographical distribution of the fossil should be consulted with reference to its phylogeny, especially in connection with its migration or dispersal, but it is also clear that the classification has to be based principally on its morphological

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1) M. Thoral (1935), Contribution à l'Etude paléontologique de l'Ordovicien inférieur de la Montagne Noire, etc. Montpellier, p. 70.

2) Howell (1935), Op. cit., p. 236.

3) Whitehouse (1936), Op. cit., p. 92. p.

characters, unless homœomorphism has been substantiated

It may, however, be said that, in the case of some morphological differences being noticed between fossils occurring in widely separated horizons or localities, they may be evaluated by more than a distinction of the same degree as is to be seen between fossils from the same locality.

As to the smooth agnostids, there is some hiatus between the Middle Cambrian and Lower Ordovician in our present knowledge of these fossils, so that the question of phylogeny and classification of the smooth agnostids, concerns, as recalled by WHITEHOUSE,[1] the Upper Cambrian species. They are *Agnostus parilis* HALL, *A. iruyensis* KAYSER, *A. bolivianus* HOEK, *Phalacroma cyclostigma* RAYMOND, and *Pseudagnostus extumidus* RAYMOND.

RAYMOND'S *parilis*[2] is represented by a convex shield that has a tubercle at its center and is bordered by a narrow, more or less convex, brim. If it is the pygidium of common use,[3] such a feature is not uncommon. It is, however, quite distinct from pygidia that resemble it in one point, that is, the position of the tubercle which is usually more anterior. The aspect of the articulating margin, on the other hand, suggests that it is a cephalon. If so, the nearest species is *Cotalagnostus altus*, which has a tubercle in the same position, and differs only in the grade of smoothing. I, therefore, think it quite possible that it is a terminal point in the specialization of *Cotalagnostus*. *Lejopyge* has a much less developed brim and non-tuberculated cephalon, except in the case of *L. laevigatus*, whose tubercle, however, is found close to the posterior margin. The *Lejopyge* branch may be parallel to the *altus-parilis* line.

Phalacroma cyclostigma RAYMOND[4] has a pygidium less convex than the preceding, and bordered by a flat brim of medium breadth. By cross light a posterior swelling is seen behind the square anterior axis, which is expanded backward. The swelling, however, is rather

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1) WHITEHOUSE (1936), Op. cit., p. 92.

2) P. E. RAYMOND (1924), New Upper Cambrian and Lower Ordovician Trilobites from Vermont, (Proc. Boston Soc. Nat. Hist. Vol. 37, No. 4,) p. 396, pl. 12, fig. 8.

3) RAYMOND considers that the usually called pygidium is really the cephalon. I do not, however, intend now to go over into this question. Hence the cephalon and pygidium are here designated according to the common usage, so as to avoid the confusion in the description.

4) RAYMOND (1924), Op. cit., p. 397, pl. 12, fig. 4.

obscure, all of which suggest that this is an extremely smooth form of *Plethagnostus*. *Pseudagnostus* (*Plethagnostus*) *clarki*[1] from Alaska, for example, except in the extent of smoothing, agrees with this species in most respects.

Pseudagnostus extumidus RAYMOND,[2] on the other hand, has a wide flange on the pygidum. A pair of posterior spines are distinct. The central body is elevated above the flange and is practically smooth except for a median tubercle. This is certainly not a *Pseudagnostus*, but most probably a peculiar form of *Phalacroma* comparable with *P. ovalis*, from which species the main difference is in the spines.

RAYMOND's three species, *Cotalagnostus* (?) *parilis*, *Pseudagnostus* (*Plethagnostus*) *cyclostigmus*, and *Phalacroma extumidus* came from the main zone of the Milton at Highgate Falls, Vermont, which belongs to the Franconian stage of the Croixan.

I have no hesitation in refering *Agnostus iruyensis*[3] to *Phalacroma*, but its Middle Cambrian age, as suggested by KAYSER, seems very doubtful. *Agnostus bolivianus* HOEK,[4] on the other hand, is rather diagnostic of *Gallagnostus*, but the axis of the thoracic segment is divided into three. The occurrence of *bolivianus* in association with *Parabolinella andina* at Salitre extends the range of *Gallagnostus* to late Upper Cambrian.

Leiagnostus was defined by JAEKEL[5] as follows:-

" Kopf -und Rumpfschild ungegliedert, das Kopfschild ganz oval gewölbt, das Schwanzschild mit flachen Limbus."

L. erraticus from a glacial boulder of the Echinosphaeritenkalk is the type species, which however, is poorly illustrated and scarcely described. So far as the diagnosis and text-figure are concerned, a generic distinction of *erraticus* from *Phalacroma* is hardly possible. The only difference is the absent median tubercle on the pygidium, because most *Phalacroma* are tuberculated. There are, however, such non-tuberculated species as *dubium* and *eskriggei*. Moreover, the in-

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1) T. KOBAYASHI (1935), The *Briscoia* Fauna of the late Upper Cambrian in Alaska with Descriptions of a few Upper Cambrian Trilobites from Montana and Nevada, (Japan. Jour. Geol. Geogr. Vol. XII,) p. 47, pl. IX, figs. 1-2.

2) RAYMOND (1924), Op. cit., p. 394, pl. 12, fig. 7.

3) E. KAYSER, (1897), Beiträge zur Kenntniss einiger palpäozoischer Faunen Süd-Amerikas, (Zeitsch. deutsch. geol. Gesell. Bd. XLIX,) p. 279, pl. VII, fig. 5.

4) HOEK (1912), Op. cit.

5) JAEKEL (1909), Op. cit, p. 401.

clusion of *nudus* in *Leiagnostus* proves that JAEKEL's *Leiagnostus* is a synonym of *Phalacroma*.

According to HOWELL,[1] *Agnostus bohemicus* NOVAK[2] is a *Leiagnostus*, which however, is represented only by the pygidium and two thoracic segments almost identical with *Phalacroma marginatus*.

Leiagnostus floulonensis HOWELL[3] from the Arenigian of Southern France resembles, on the other hand, *Gallagnostus* rather than *erraticus*. It, however, differs from *Gallagnostus* in the prominent median tubercle and developed flanges. In these respects it is more related to *Geragnostus* than to *Gallagnostus*, and it is not improbable that *G. languidus*[4] will turn out to be *floulonense*, through obliteration of the relief. I wonder, if such a form as *Agnostus consors* HOLUB[5] from the Bohemian Tremadoc might not be a *Trinodus*, the axis of whose pygidium is smoothed out behind.

Finally, *Agnostus similaris* BARRANDE[6] from d_1 has a smooth convex cephalon without a brim or pygidium provided with a large swollen axis and a narrow brim. Combination of these characters does not fit in with any generic diagnosis. *Sphaeragnostus* was proposed for it by HOWELL and RESSER, and *S. gaspensis* was added to it by COOPER and KINDLE.[7] I think that *Agnostus cingulatus* OLIN[8] belongs also to this genus. If the brim were removed from the pygidium of *Sphaeragnostus*, the marvelous resemblance of *Phalacroma* (?) *eskriggei* to this genus could scarcely be overlooked.

The smooth agnostids are the group most difficult to study, and at present there are many gaps in the chains of our knowledge. But the present study has thrown a little light on the polyphyletic origin of the smooth agnostids.

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1) HOWELL (1935c), Op. cit., p. 236.

2) O. NOVAK and J. PERNER (1918), Die Trilobiten der Zone D-d1γ, von Prag und Umgebung, (Palaeontographica Bohemiae Nr. IX,) p. 33, pl. I, fig. 7.

3) HOWELL (1935c), Op. cit., p. 236, pl. 23, figs. 17-18.

4) HOWELL (1935c), Op. cit., p. 237, pl. 23, figs. 19-21.

5) K. HOLUB (1912), Nachträge zur Fauna des *Euloma*-Horizontes in der Umgebung von Rokycan, (Bull. intern. de l'Acad, des Sciences Bohême,) p. 2, fig. 5.

6) J. BARRANDE (1872) Système silurien du Centre de la Bohême, Suppl. to Vol. I, pp. 144, pl. 14, fig. 17.

7) G. A. COOPER and C. H. KINDLE (1936), New Brachiopods and Trilobites from the Upper Ordovician of Percé, Quebec, (Jour. of Pal. Vol. 10,) p. 361, pl. 52, figs. 15, 17, 22, 23, 35.

8) E. OLIN (1906), Om de *Chasmops*-kalken och *Trinucleus*-kiffern Motsvarande Bildningarne i Skåne, (Lund Universitets Årskrift, N. F. Afdeln. 2, Bd. 2, Nir 3,) p. 72, pl. IV, fig, 17.

As a result, it may be said that the Phalacromidae is more persistent than the *Lejopyge*-line. The latter appears to terminate in the Upper Cambrian with *Cotalagnostus* (?) *parilis* on the one hand, while a moderate display of the former can be recognized in the Upper Cambrian on the other. *Phalacroma extumidus, P. iruyensis,* and *Gallagnostus bolivianus* are the representatives of the family. The branch, however, dies out in Upper Cambrian, leaving *Sphaeragnostus,* which is probably derived from *Phalacroma* (?) *eskriggei,* and ends in the Upper Ordovician with *S. gaspensis.*

Besides the two main lines of evolution that originated in the Middle Cambrian, small off-shoots have been discovered in the Upper Cambrian and Ordovician. One is *Pseudagnostus* (*Plethagnostus*) *cyclostigmus,* which exhibits the terminus of the smoothing in the Pseudagnostidae; another is Arenigian *Geragnostus* (?) *floulonensis,* which possibly indicates the same point in the Geragnostidae.

Family Phalacromidae Corda

Genus PHALACROMA Corda, 1847

Phalacroma atuberculata, new species

Plate VII, Figures 3-4

This species is represented by two shields, subspherical, considerably convex, rounded and truncated at the articulatory margin. The maximum breadth is located at a point about two-thirds across from the margin. The brim is well-defined, narrow and depressed. A pair of pits on the articulatory margin indicates the axial breadth, which occupies about two-fifths of the margin.

Under a high magnifier the outline of the axis is faintly impressed on the holotype. It is as long as two-thirds the length of the shield, more or less parallel-sided and rounded at the distal end. A transverse groove divides the axial lobe into two, between which the proximal one appears to be subdivided into two by another groove. These grooves, however, are interrupted at the middle of the axis—an aspect that suggests the location of the median tubercle, but which is in turn flattish and indistinct.

Judging from these observations, I am inclined to believe that the shield under consideration is more likely a pygidium rather than a cephalon.

Comparison:—In the outline of the pygidium and breadth

of brim this is more similar to *Phalacroma iruyensis*[1] than any Paradoxidian species of the genus. However, it differs from these in its indistinct tubercle. Because of this, it agrees with *Phalacroma* (?) *dubium*,[2] but the brim does not increase its breadth toward the posterior as in *dubium*.

Formation and locality:—Late Upper Cambrian green sandstone; Tambo Guanacuno and (?) west side of Abra de Escayache, Bolivia.

Genus GALLAGNOSTUS Howell, 1935

Gallagnostus bolivianus (Hoek)

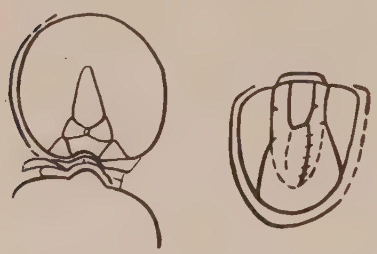
Plate II, figures 1-2; text-figure 17

1912, *Agnostus bolivianus* Hoek, Op. cit., p. 212, pl. VII, fig. 6.
1935, *Gallagnostus bolivianus* Howell Op. cit., pp. 227.

The cephalon and pygidium of this species are so similar that it is rather difficult to distinguish the two. They are gently convex, smooth, and surrounded by a narrow, flat, and depressed brim.

The holotype may be more or less deformed, but the thoracic segment is well preserved. The axial portion occupies more than half the breadth of the thorax and is divided into three by an elevated tubercle and faint furrows.

The glabellar outline is very faintly impressed on the paratype, which was sketched by the writer with the aid of a camera-lucida and illustrated in text-figure 17. The glabella is conical, wide at the base, abruptly tapering forward, and trilobed by two transverse furrows. The basal lobes are subtriangular and relatively large. The median tubercle is minute and almost indiscernible.



Text-figure 17. *Gallagnostus bolivianus* (Hoek)
Text-figure 18. *Pseudagnostus* (*Rhaptagnostus* ?) *semiovalis* Kobayashi, (nov.) (Both Sketches)

In none of the pygidium in hand can be distinctly seen the outline of the axial lobe. But, as far as I can determine from the holotype, it appears to be conical and as long as two-thirds the length of the pygidium.

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1) Kayser (1897), Op. cit., p. 279, pl. VII, fig. 5.
2) Whitehouse (1936), Op. cit., p. 95, pl. I, figs. 13-15.

Comparison:—With regard to the outline and convexity of the carapace, narrow brim and wide axis of the thorax, this species agrees with *Gallagnostus geminus*,[1] but differs in the tuberculated cephalon and thoracic segments. In these respects this may even be closer to *Gallagnostus* (?) *thorali*.[2] However, the shield is much more convex.

Formation and locality:—Late Upper Cambrian black shale of Salitre, South Bolivia.

Family Pseudagnostidae Whitehouse

The main evolutional line of agnostid is represented by the Agnostidae, which usually has a subconical axial lobe of medium size on the cephalon as well as on the pygidium. Besides the tendency to obsoletion of surface relief above described, there are several that branch off from the Agnostidae line. One trend is directed to the anterior expansion of the glabella by means of which *Pleuroctenium* and *Paragnostus* are introduced.

Another trend is the posterior expansion of the axial lobe on the pygidium, in which two ways may be distinguished. One is the expansion of the axis itself and the other the addition of accessary diagnonal furrows which outline the "*posterior pseudolobe*." Thus, it appears that the anterior lobe of the axis continues to the posterior pseudolobe, but the true posterior lobe is in fact to be found within the pseudolobe, which, however, is not expanded in itself.

Examples of the former evolutional trend are *Homagnostus* Howell and *Oncagnostus* Whitehouse. Both have the trilobed axis of the pygidium similar to that of the Geragnostidae, in which, however, the axis is larger and expanded at its posterior end.

Posterior expansion is typified in the Pseudagnostidae. The diagonal accessory furrow is such a significant feature confined to the family that it is never seen, not only in other agnostids, but in all other trilobites, from which I believe that Whitehouse's family designation for this group of agnostids is quite correct. In this family the axis on the cephalon and pygidium is trilobed, but the trilobation is not always distinct. In several forms the square anterior axis of the pygidium is divided only in a pair of pits on the lateral sides.

Whitehouse[3] combined *Pseudagnostus* Jaekel, *Plethagnostus*

1) Howell (1935c), Op. cit., p. 227, pl. 22, figs. 21.
2) Howell (1935c), Op. cit., p. 227, pl. 22, figs. 19-20.
3) Whitehouse (1936), Op. cit., 97.

CLARK, and *Rhaptagnostus* WHITEHOUSE and placed them in this family. The outline of the posterior axis is practically indiscernible in *Plethagnostus*, but is traceable in *Pseudagnostus*. However, the disappearance of the axial outline is gradual and an arbitrary line, after all, should be drawn between the two genera. Therefore, I am inclined to believe that *Plethagnostus* is no more than a subgenus of *Pseudagnostus*.[1]

Rhaptagnostus is based on *Agnostus cyclopygeformis* SUN[2] and the subellliptical arrangement of foraminas on the pygidium is considered by WHITEHOUSE, to be a diagnostic character of the genus. It is highly probable that these foraminas are caused by muscular attachment so that the body outlined by them indicates the posterior half of the axis.

I have never seen such a row of foraminas in any specimen of pseudagnostids except in *Pseudagnostus cyclopygeformis* from South Chosen[3] and in *Pseudagnostus semiovalis* here described, but since, in both of them the carapace is altered into some kind of iron-oxide, it is uncertain, whether or not, the foramina was originally impressed on the dorsal side. I have seen this kind of structure also in *Agnostus* (*Ptychagnostus* ?) *orientalis*,[4] which is represented by a single pyg·dium, instead of cephalon as erroneously mentioned in my previous paper. At least five sets of pits are observed on it, but the specimen is a cast. I have not seen any agnostids with rows of foraminas impressed on the dorsal side. If SUN's observation was made on an inexfoliated surface, the row of foraminas is certainly a significant feature.

If the true posterior axis of the pygidium is so obliterated as in *Plethagnostus*, it is very difficult to determine whether the posteriorly expanded part reveals the true axis or the pseudolobe, but if it is the latter, its outline should be large enough to agree with that of *Pseudagnostus*.

Agnostus securiger LAKE[5] is a puzzling form. LAKE compared it with *Peronopsis integer*, but I think that it is certainly more allied to *Pseudagnostus*, not only because of the trilobed glabella, but also the aspect of the posterior expansion of the axis on the pygidium. It is most probably a *Plethagnostus* with irregular divergent furrows on

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1) KOBAYASHI (1935 b), Op. cit., p. 46.

2) Y. C. SUN (1924), Contributions to the Cambrian Faunas of North China, (Palaeontologia Sinica Ser. B, Vol. I, Fasc. IV,) p. 26, pl. II, figs. 1 a–h.

3) KOBAYASHI (1935 a), Op. cit., p. 111, pl. III, figs. 12–14.

4) KOBAYASHI (1935 a), Op. cit., 105, pl. XIV, figs. 11–12.

5) LAKE (1906), Op. cit., p. 20, pl. II, fig. 10.

the side lobes. Through the last mentioned character this species, however, is distinguished from other genera of the Pseudagnostidae. Therefore *Sulcatagnostus* (nov.) is proposed here on the basis of *Agnostus securiger* LAKE.

Finally, the Pseudagnostidae was considered to belong to the Upper Cambrian branch, but in reality it appears already in the Middle Cambrian of South Chosen, as reported in my monograph.[1] The present collection from South America extends the upper limit of the family to Lower Ordovician.

Genus PSEUDAGNOSTUS JAEKEL, 1909

1909 *Pseudagnostus* JAEKEL, Op. cit., p. 400.
1923 *Plethagnostus* CLARK, A Group of new Species of *Agnostus* from Levis, Quebec, (Canadian Field Naturalist, Vol. XXXVII, No. 7,) p. 174.
1924 *Plethagnostus* CLARK, Paleontology of the Beekmantown Series at Levis, Quebec, (Bull. Am. Pal. Vol. 10, No. 41,) p. 16.
1933 *Pseudagnostus* KOBAYASHI, Upper Cambrian of the Wuhutsui Basin, Liaotung with Special Reference to the Limit of the Chaumitian (or Upper Cambrian) of Eastern Asia, and its Subdivision, (Japan. Jour. Geol. Geogr. Vol. 11,) p. 97.
1935a *Pseudagnostus* KOBAYASHI, Op. cit., 107.
1935b *Pseudagnostus* KOBAYASHI, Op. cit., p. 46.

Genotype:—*Agnostus cyclopyge* TULLBERG.

Remark:—The following species are referable to this genus:—

Agnostus josepha HALL, 1836 (Franconia of the Upper Mississippi Valley)

Agnostus communis HALL and WHITFIELD, 1877 (Potsdam black limestone of White Pine District, Nevada)

Agnostus neon HALL and WHITFIELD, 1877 (Potsdamian limestone of Eureka District, Nevada)

Agnostus douvillei BERGERON, 1899 (Kushan shale of Eastern Asia)

Plethagnostus gyps CLARK, 1923 (Upper Cambrian boulder of Levis, Quebec)

Phalacroma cyclostigma RAYMOND, 1924. (Main zone of the Milton, in Vermont)

? *Agnostus cyclopygeformis* SUN, 1924 (*Kaolishania* and *Tsinania* zones of Eastern Asia)

Pseudagnostus orientalis KOBAYASHI, 1931 (*Chuangia* zone of Eastern Asia)

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1) KOBAYASHI (1935a), Op. cit., p. 108, pl. XIV, figs. 6-10.

Pseudagnostus primus KOBAYASHI, 1935 (*Olenoides*-zone of South Chosen)

Pseudagnostus (*Plethagnostus*) *clarki* KOBAYASHI, 1935 (*Parabriscoia* zone of Alaska)

Pseudagnostus vastulus WHITEHOUSE, 1936 (*Anorina*, i. e. *Eoasaphus*,[1] stage of Queensland)

Pseudagnostus neperus WHITEHOUSE, 1936 (*Elrathiella* stage of Queensland)

Pseudagnostus (*Rhaptagnostus* ?) *semiovalis* KOBAYASHI (nov.) (Basal Ordovician of Obispo, South America)

In *cyclopyge* the shield is moderately convex, bordered by a brim of medium breadth. The glabella is trilobed and the middle one carries a medium tubercle. Its pygidium is provided with a pair of rear spines; its axis divided into a square anterior and long triangular posterior lobes, but the latter is quite obscure and the posterior pseudolobe is well marked by accessary diagonal furrows.

Orientalis, communis, neon, vastulus and *neperus* have posterior spines, but *cyclopygeformis, gyps, clarki* and *cyclostigma* have none. The surface relief is quite reduced in the last two species.

The oldest species is *primus* which is large, long, subovate in outline, and aspinose. The furrows are mostly very shallow. As stated in my previous paper,[2] the lobation of the glabella and the size of the rear spine are quite variable in *douvillei*, but usually have a wide, frequently convex margin, and no preglabellar furrow. It is remarkable that the posterior glabella is divided into two lobes, deepening the constrictions, and then extending transverse furrows from them. This appears to suggest that the trilobed glabella is introduced by the addition of a transverse furrow.

A study of the majority of these species has convinced me that the outline, surface relief and rear spine vary within the genus. In *douvillei* at any rate the spine has no specific value. The outline of the posterior pseudolobe as well as those of the true lobe reduce their prominence gradually. I was first led to retain CLARK's *Plethagnostus* as a subgenus owing to the obscure posterior axial lobe and absence of the rear spine, instead of the strength of the accessory diagonal furrow, but now I am inclined to believe that none of

1) T. KOBAYASHI (2936), Notes on Nomenclature of some Cambro-Ordovician Genera, (Jour. Geol. Soc. Japan, Vol. 43,) p. 922.

2) KOBAYASHI (1935a), Op. cit., p. 109.

these distinctions is adequate for drawing a sharp boundary between *Pseudagnostus* s. str. and *Plethagnostus.*

Pseudagnostus (*Rhaptagnostus*?) *semiovalis*, new species

Plate II, figures 8–9; text-figure 18

This species is represented by two pygidia, long, semiovate, and gently convex. The holotype (pl. II, fig. 8,) is laterally compressed and deformed. The axial lobe is wider than one-third the pygidium, subsquare in the anterior half, semi-elliptical, obscured in the posterior, and ending at a point about one-fifth the length of the pygidium from the posterior extremity; the axial grooves rather distinct in the anterior and continue to the diagonal accessory furrows, which are gradually faded behind; no transverse groove, but pits are present on the sides of the axis, while the median tubercle is long and prominent; the marginal brim narrow, but gradually increases its breadth backward; no postero-lateral spine is to be seen.

Five small pits more or less transversely elongated are observed in the extension of the median tubercle, the pits referring to *Rhaptagnostus,* but since the carapace has been altered into iron-oxide, the pits might not have existed on the original dorsal surface.

The paratype pygidium (pl II, fig. 9) shows the doublure, wide along the posterior margin, but narrowing abruptly forward.

Pseudagnostus was believed to be confined to the Upper Cambrian, but a species, *primus,* was discovered from the Middle Cambrian of of South Chosen. So far as the pygidium is concerned, the present species is typical of *Pseudagnostus* and may be the latest survivor of the genus.

In the semiovate outline and absent lateral spine, this most resembles *primus,* but the obsolete transverse furrow and long median tubercle located at a more anterior point distinguishes it from *primus.*

Formation and locality:—Basal Ordovician dark gray shale (*Kainella* zone); west of Obispo.

Family Geragnostidae Howell

When Jaekel[1] revised the agnostids in 1909, he created the Metagnostidae to include *Metagnostus* and *Hypagnostus,* and the Parag-

1) Jaekel (1909), Op. cit.

nostidae to include *Paragnostus, Dichagnostus, Diplagnostus,* and *Mesagnostus.* Subsequently, however, *Metagnostus, Paragnostus, Dichagnostus,* and *Mesagnostus* were synonymized by RAYMOND[1] with *Arthrorhachis, Condylopyge, Pleuroctenium,* and *Peronopsis* respectively, the names already established by CORDA in 1847. Consequently, the Metagnostidae and Paragnostidae were replaced by the Arthrorhachidae and Condylopygidae.

Lately HOWELL[2] combined *Condylopyge* and *Pleuroctenium* with *Mallagnostus* in his Mallagnostidae and brought *Peronopsis* into his Spinagnostidae. At the same time he instituted three new families, namely, Geragnostidae, Micragnostidae, and Trinodidae and placed *Geragnostus* in the first, *Micragnostus* and *Anglagnostus* in the second, and *Trinodus* in the third family.

In contrast to this, WHITEHOUSE[3] next year grouped *Geragnostus, Micragnostus* and *Anglagnostus,* in addition to *Diplorrhina* and *Peronopsis,* into the Geragnostidae, but left *Trinodus* in the Trinodidae, to which latter he tentatively added *Hypagnostus* and questioned the validity of the name, Trinodidae. Furthermore, he tied *Diplagnostus* with *Tomatagnostus* and *Enetagnostus* in his Diplagnostidae. In the same year WESTERGÅRD[4] instituted the Peronopsidae for TULLBERG's Fallaces section, but gave no further information.

Thus, the nomenclature and classificatory position of the genera are in great confusion. Before entering into the discussion, it may be appropriate to list the concerned genera and their type species below, (genera marked by asterisks are either invalid or superflous):—

Trinodus McCOY, 1846 (*Trinodus agnostiformis* McCOY)
**Diplorrhina* CORDA, 1847 (*Diplorrhina sirius* CORDA)
Condylopyge CORDA, 1847 (*Agnostus rex* BARRANDE)
Pleuroctenium CORDA, 1847 (*Agnostus glanulatus* BARRANDE)
Peronopsis CORDA, 1847 (*Agnostus integer* BARRANDE)
**Mesospheniscus* CORDA, 1847 (*Mesospheniscus cuneifera* CORDA)
**Arthrorhachis* CORDA, 1847 (*Agnostus tardus* BARRANDE)
**Paragnostus* JAEKEL, 1909 (*Agnostus rex* BARRANDE)
**Dichagnostus* JAEKEL, 1909 (*Agnostus glanulatus* BARRANDE)

1) RAYMOND (1913), Op. cit., p. 88.
2) HOWELL (1935c), Op. cit., p. 27.
3) WHITEHOUSE (1936), Op. cit.
4) WESTERGÅRD (1936), Op. cit.

Diplagnostus JAEKEL 1909 (*Agnostus planicauda* ANGELIN)
**Mesagnostus* JAEKEL, 1909 (*Agnostus integer* BARRANDE)
Hypagnostus JAEKEL, 1909 (*Agnostus parvifrons* LINNARSSON)
**Metagnostus* JAEKEL, 1909 (*Agnostus erraticus* JAEKEL)
Fallagnostus HOWELL, 1935 (*Fallagnostus llayaci* HOWELL)
Mallagnostus HOWELL, 1935 (*Agnostus desideratus* WALCOTT)
Spinagnostus HOWELL, 1935 (*Spinagnostus frankliensis* HOWELL)
Quadragnostus HOWELL, 1935 (*Quadragnostus solus* HOWELL)
Triplagnostus HOWELL, 1935 (*Agnostus gibbus* LINNARSSON)
Geragnostus HOWELL, 1935 (*Agnostus sidenbladhi* LINNARSSON)
**Micragnostus* HOWELL, 1935 (*Agnostus calvus* LAKE)
**Anglagnostus* HOWELL, 1935 (*Agnostus dux* CALLAWAY)
Tomatagnostus HOWELL, 1935 (*Agnostus fissus* LUNDGREN)
Solenagnostus WHITEHOUSE, 1936 (*Agnostus longifrons* NICHOLSON)
Oncagnostus WHITEHOUSE, 1936 (*Agnostus hoi* SUN)
Euagnostus WHITEHOUSE, 1936 (*Euagnostus opimus* WHITEHOUSE)
Enetagnostus WHITEHOUSE, 1936 (*Enetagnostus humilis* WHITEHOUSE)

The inclusion of *tardus* and *erraticus* in *Trinodus*[1] nullifies *Arthrorhachis* and *Metagnostus* and consequently the Arthrorhachidae and the Metagnostidae.

Diplorrhina is based upon *sirius*, while *rotundata, triplicata, orion, umbonata, elliptica, asperula, solenophora, monas, affinis* and *cristata* are referred to it by CORDA. BARRANDE,[2] however, has stated that these species of *Diplorrhina*, in addition to *Mesospheniscus cuneifer*, indicate different ontogenetical stages of *integer*. POMPECKJ[3] subsequently described a spiny form of *integer*, namely, var. *spinosa*. Not only this variety, but HICK's *cambriensis* in 1872[4] (non 1871) are synonymized with *integer* by LAKE,[5] the action being endorsed by ILLING.[6] Thus, it may be said that CORDA's *Mesospheniscus* and *Diplorrhina* are invalid names and that *Peronopsis*, whose type species is *integer*, stands. The species occurs in Oeland in the *oelandicus* beds.[7]

Since *Condylopyge* is involved in the Mallagnostidae, I first thought that this family name might be invalidated by the Condy-

1) HOWELL (1935c) Op., cit., p. 234.
2) BARRANDE (1852), Op. cit., pp. 900–903.
3) POMPECKJ (1896), Op. cit., p. 522, pl. XVI, fig. 6.
4) HICKS (1872), Op. cit., pl. V, fig. 1.
5) LAKE (1906), Op. cit., pp. 18–19.
6) ILLINGS (1915), Op. cit., p. 416.
7) WESTERGÅRD (1936), Op. cit., p. 28, pl. I, figs. 16–18.

lopygidae, but probably both stand. According to HOWELL,[1] *Agnostus desideratus* WALCOTT,[2] on which *Mallagnostus* is founded, is represented by a unique pygidium, instead of a cephalon as believed by WALCOTT. This pygidium has a cylindrical unfurrowed axis, on which basis *Mallagnostus* forms no comparison with *Condylopyge* and *Pleuroctenium*, as both are characterized by a segmented axis that is expanded at the rear. It is of course a question what sort of a cephalon should go with *desideratus*, but so far as I can see from the pygidium, it does not differ much from that of *Fallagnostus*.

In the Lower Cambrian, the agnostids are exceedingly scarce. WALCOTT in his monograph of the Lower Cambrian faunas,[3] had only three species, *Agnostus desideratus*, *A.* (?) *nobilis*, and *Agnostus* sp., of which *nobilis* was selected by RAYMOND[4] for the type species of *Weymouthia*. *Desideratus*, as mentioned above, is the type species of *Mallagnostus*. *Agnostus* sp. from Washington Co., N. Y. is represented by a cephalon and pygidium both semi-ovate in outline and bordered by a broad brim. The glabella is subconical and bilobed, and the axis of the pygidium is not segmented, but has a mediun tubercle.

The nearest trilobite to agnostids are the Eodiscidae and Pagetidae. The thoracic segments number three in the former and two in the latter family. The clear-cut preglabellar furrow or depression is rarely seen in the former, but rather frequently in the latter, but so far as I am aware, none of the non-agnostidian trilobites, except *Liostracina* and an undescribed genus from Eastern Asia, have such forms. Therefore, I am of the opinion that the median preglabellar furrow is an acquired character, and that the conical or cylindrical axis is the primary aspect of the agnostid.

The nature of such a longitudinal furrow, however, is uncertain, that is to say, whether it is an impression of the sagittal suture or whether it indicates something else. Anyhow, it is accepted that the furrow is a special feature dominant in a certain group of the agnostid. This may be one reason why TULLBERG distinguished his Fallaces and Longifrontes sections.

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1) HOWELL (1935c), Op. cit., p. 228.

2) C. D. WALCOTT (1890), The Fauna of the Lower Cambrian or *Olenellus* zone, (U. S. Geol. Surv. 10th Ann. Rept. Pt. I.) p. 929, pl. 80, fig. 5.

3) WALCOTT (1890), Op. cit., pp. 669–630, pl. LXXX, figs. 5–6, 8.

4) P. E. RAYMOND (1913), On the Genera of the Eodiscidae, (Ottawa Naturalist, Vol. XXVII, No. 8,) p. 103.

The furrow is confined to the anterior of the glabella in *Tomatagnostus* but right across the anterior lobe in *Diplagnostus* and *Enetagnostus.* The furrow on the preglabellar field, however, is absent in *Tomatagnostus* and *Diplagnostus*, although well marked on *Enetagnostus.* WHITEHOUSE,[1] however, ignored the presence or absence of the preglabellar median furrow as a family characteristics of the Diplagnostidae.

WESTERGÅRD[2] included the furrowed and non-furrowed forms in *Agnostus pisiformis obesus* and stated that the "groove in front of the glabella, even in the typical specimens, does not always seem to continue as far as the margin."

Thus, the furrow under consideration is regarded in various ways by authors. At any rate it is an evolutional character seen in the Spinagnostidae, Agnostidae, and Diplagnostidae. As to the furrow, the third family is distinct from the other two, but the first and second families may be more continuous with gradual changes, from which I am inclined to accept the Agnostidae as signifying the main line of evolution and the Spinagnostidae or Peronopsidae as probably being no more than divisions within it.

I believe that *Hypagnostus* does not belong to the Trinodidae, because *Trinodus* arises from the Geragnostidae by a shortening of the axial lobe of the glabella, and *Hypagnostus* by the disappearance of the anterior lobe of the glabella from the *Spinagnostus* section of Agnostidae. The process is half-way completed in LORENZ's *Agnostus parvifrons*[3] from Shantung.

If such smoothing effects the whole of the carapace, the *Lejopyge* group is introduced. The glabellar front is developed in the Condylopygidae, but if the expansion of the axis is confined to the posterior lobe of the axis on the pygidium, then the aquired forms are the *Oncagnostus*, and *Triplagnostus* groups between which the axis is pointed behind in the latter but rounded in the former.

The Geragnostidae and Micragnostidae are both well characterized by the absent preglabellar furrow and subcylindrical or subconical axes on the cephalon and pygidium. They differ somewhat, but HOWELL himself mentions that they merge into one. Therefore, with

1) WHITEHOUSE (1936), Op. cit., p. 90.

2) A. H. WESTERGÅRD (1922), Sveriges Olenidskiffer, (Sverig. Geol. Unders. Ser. Ca, Nio 18,) p. 193, pl. 1, figs. 4, (5, 6 ?).

3) T. LORENZ (1906), Beiträge zur Geol. u. Paläont von Ostasien II, Paläont. Teil, (Zeitsch. deutsch. geol. Gesell. Bd. 58,) p. 98, pl. 4, figs. 9a-b; pl. 5, figs. 10-11.

WHITEHOUSE, I am rather inclined to combine the two families into one, and also *Geragnostus, Micragnostus* and *Anglagnostus* into one genus. On the other hand, *Trinodus* is fairly different from *Geragnostus* in the length of the pygidial axis and other features. The former is a derivative of the latter and a good genus, but separation of family rank is not warranted.

The evolutional line of the Geragnostidae branched off from a certain form of Agnostidae, including *Peronopsis*, and developed in the Upper Cambrian and Ordovician periods.

Genus GERAGNOSTUS HOWELL, 1935

1935 *Geragnostus* HOWELL, Jour. Pal. Vol. 9, p. 231.
1935 *Micragnostus* HOWELL, Op. cit., p. 233.
1935 *Anglagnostus* HOWELL, Op. cit., p. 233.

The genus is well characterized by the gently convex shield surrounded by the brim, the absence of a median preglabellar furrow, and the presence of a subcylindrical axial lobe rounded at the distal end. The axial lobe has mostly a median tubercle and is primarily trilobed. The glabella has a pair of basal side-lobes. The surface is smooth.

The glabella is faintly trilobed in *A. sidenbladhi*, but the second transverse furrow is rather obscure. It disappears completly in *A. calvus* and *A. dux*. The third axial lobe of the pygidium is longer in *sidenbladhi* than in *calvus*, and the lobe is united with the second one through obsoletion of the second transverse furrow in *dux*. The axial lobe occupies about two-thirds the length of the cephalon or pygidium in *sidenbladhi* and *calvus*, but is much shorter in *dux*.

A division of the three genera i. e. *Geragnostus, Micragnostus* and *Anglagnostus* is, however, a matter of personal opinion, because the difference is rather gradual among the majority of the species. I believe that no more than a subgeneric distinction is required.

Trinodus is, on the other hand, rather apart from *Geragnostus*, with regard to the absence of the transverse furrow on the glabella and short axis, which is about half as long as the pygidium. That *Trinodus* indicates a terminus of the Geragnostidae is highly probable.

The specific list of *Geragnostus* follows:

Agnostus princeps var. *rudis* SALTER (partim), 1864. (Upper *Lingula* Flag of England and the *Peltura scarabœoides acutidens* and *P. minor* zone of Sweden.)

(?) *Agnostus obtusus* BELT, 1868 (Upper *Lingula* Flag of England.)

(?) *Agnostus bavaricus* BARRANDE, 1868 (Tremadocian of Bavaria)

Agnostus sidenbladhi LINNARSSON, 1868 (Tremadocian of Sweden, Norway, and England) [Type species of *Geragnostus*]

Agnostus dux CALLAWAY, 1877 (Tremadocian of England) [Type species of *Anglagnostus*]

? *Agnostus tilcuyensis* KAYSER, 1878 (Upper Cambrian of Argentina)

Agnostus bisectus MATTHEW, 1892 (Canadian of New Brunswick)

Agnostus callavi RAW (MS), in LAKE 1906 (Tremadocian of England)

Agnostus calvus LAKE, 1906, (Tremadocian of England) [Type species of *Micragnostus*]

Agnostus sidenbladhi var. *urceolatus* SEGERBERG and MOBERG, 1906 (Tremadocian of Sweden)

Agnostus rudis var. *holmi* WESTERGÅRD, 1822 (*Peltura scarabœoides* and *Parabolina longicornis* zones of Sweden)

Agnostus insuetus RAYMOND, 1924 (Main zone of the Milton in Vermont)

Agnostus calvus var. *latemarginalis* STUBBLEFIELD and BULMAN, 1927 (Tremadocian of England.)

Agnostus chiushuensis KOBAYASHI, 1931 (Wanwanian of South Manchuria)

Geragnostus sidenbladhi var. *gallicus* HOWELL, 1935 (Middle Tremadocian of Herault, South France)

Geragnostus occitanus HOWELL, 1935 (Lower Arenigian of Herault, South France)

Geragnostus callavei var. *mediterranens* HOWELL, 1935, (ditto.)

Geragnostus pusio HOWELL, 1935 (ditto.)

Micragnostus languedocensis HOWELL, 1935 (ditto.)

Anglagnostus barroubioensis HOWELL, 1935 (ditto.)

Geragnostus languidus HOWELL, 1935 (Arenigian *Calymene* shale of Herault, South France)

Geragnostus boutouryensis HOWELL, 1935 (ditto.)

Geragnostus manifestus HOWELL, 1935 (ditto.)

Agnostus subobesus KOBAYASHI, 1936 (Late Upper Cambrian of Yukon-Alaska boundary)

Geragnostus tullbergi KOBAYASHI, (nov.) (Late Upper Cambrian of

Guanacuno and Abra de Chorcoya, South America)

Geragnostus quadratus KOBAYASHI, (nov.) (Tremadocian of Cuesta de Erquis, Tarija and Guanacuno, South America.)

It is most probable that *Geragnostus* was derived during the middle Upper Cambrian from a certain *Peronopsis* or *Agnostus*, such as *Agnostus pisiformis obesus* of the early Upper Cambrian. BELT's variety, *obesus*, seems, however, to be under great confusion at present.

LAKE[1] synonymised TULLBERG's *socialis*, 1880,[2] with BELT's *obesus*, 1867,[3] which action was endorsed by WESTERGÅRD.[4] LAKE and WESTERGÅRD's *obesus*, however, includes at least two different forms. One (A), represented in fig. 13, plate I by LAKE, and in fig. 4 plate I, by WESTERGÅRD, has a median preglabellar furrow and sub-cylindrical axis of the pygidium; the other (B) shown in fig. 14 by LAKE and in fig. 15 by WESTERGÅRD, has no median furrow and the axis of the pygidium is much larger and quite expanded behind.

Form A is not essentially distinct from *pisiformis* except for the outline and size of the axial lobe. In this respect the form A agrees with *Agnostus pisiformis pater* HOLM and WESTERGÅRD,[5] but in this form the median furrow does not run straight across the preglabellar field as in *pater*.

The form B, on the contrary, belongs to the same group as *Agnostus hoiformis* KOBAYASHI.[6]

BELT, when he established his variety, illustrated two cephala and pygidia. One pair in figs. 4a and 4c are compressed in a longitudinal direction and the other in figs. 4b and 4d in a lateral direction. In the longitudial and cylindrical axis of the pygidium, both BELT's specimens agree with the form A rather than the form B, but both cephala illustrated show the median preglabellar furrow clearly. I consequently wonder, if BELT's form (C) may not be closer to *rudis* than to the form A of *obesus*.

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1) LAKE (1906), Op. cit., p. 9.

2) TULLBERG (1880), Op. cit.

3) BELT (1867), New Trilobites from North Wales, (Geol. Mag. IV), p. 295, pl. XII, figs. 4a-d.

4) WESTERGÅRD (1922), Op. cit., p. 116.

5) HOLM and WESTERGÅRD (1930), Op. cit., p. 9, pl. I, fig. I, pl. IV, figs. 9-10.

6) T. KOBAYASHI (1933), Upper Cambrian of the Wuhutsui Basin, Liaotung, with Special Reference to the Limit of the Chaumitian (or Upper Cambrian) of Eastern Asia and its Subdivision, (Japan. Jour. Geol. Geogr. Vol.) p. 97, pl. X figs. 1-3.

TULLBERG's *socialis* was not originally illustrated, but its pygidium is presumably similar to that of form B, because the third axial lobe is said to be large, swelling out and rounded at the rear. BRÖGGER[1] and POMPECKJ[2] combined this kind of pygidium with cephalon of form A, the species then being quite similar to *Agnostus hoi* SUN[3] for which *Oncagnostus* was established by WHITEHOUSE.[4]

LAKE and WESTERGÅRD's two forms are indicated by complete carapaces, but the cephala and pygidia of the other authors are detached from one another. There still remains therefore some question of the combination of the detached carapaces into the forms C and D. I am not in a position to go into a thorough and extensive revision of *socialis* and *obesus*, but the question whether *obesus* is a composite or variable species requires careful study. If these combinations are as sumed to be correct, then there are four different forms to be distinguished in *obesus* or *socialis* as follows:—

A) A form of *obesus* by LAKE and WESTERGÅRD.

B) B form of *obesus* by LAKE and WESTERGÅRD.

C) *obesus* by BELT.

D) *socialis* by TULLBERG, BRÖGGER and POMPECKJ

Forms B and D are probably the European equivalents of *hoi* and *hoiformis* respectively. Since they differ so much from forms A and C in the outline of the axis on the pygidium, such a generic separation is advisable, provided some break is recognized between the two morphological series.

This step has already been taken. HOWELL has established *Homagnostus*[5] for *obesus*, which was the form D. WHITEHOUSE's *Oncagnostus* is based on *Agnostus hoi* SUN, so that the form B is probably included in it. The form C agrees most with *rudis*, which is a *Geragnostus*. The A form more resembles *pater* than *pisiformis* s. str.

According to HOLM and WESTERGÅRD, *pater* is older than *pisiformis*. It occurs in the *forchhammer* zone of Scania and the *laevigatus* zone (?) of Nerike.

1) W. C. BRÖGGER (1882), Die Silurischen Etagen 2 und 3, u. s. w. p. 56, pl I. figs. 102-c.

2) J. F. POMPECKJ (1890), Die Trilobiten-Fauna der Ost- und Westpreussischen Diluvialgeschiebe, (Beitr. zur Naturkunde Preuss. 7,) p. 15, pl. IV, figs. 24a-b.

3) SUN (1924), Op. cit., p. 28, pl. II, figs. 2a-d.

4) WHITEHOUSE (1936), Op. cit., p. 84.

5) HOWELL (1935 a), Op. cit., p. 15, figs. 11-12.

Furthermore *pater* is found associated with *Centropleura* and *Anomocare* in Bennett Island. The *pisiformis* zone indicates the transition from the Middle to the Upper Cambrian. Other trilobites therein reveal a peculiar assemblage, consisting of *Schmalenseeia, Proceratopyge,* and *Acrocephalites.* So it is in Eastern Asia. The Kushan fauna, which marks the top of the Middle Cambrian, is composed of such aberrant genera as *Stephanocare, Damesella, Blackwelderia, Drepanura, Dorypygella, Teinistion* and *Liostracina.*

Obesus occurs in the succeeding *Olenus* and *Orusia* zones. The common *Homagnostus* and *Oncagnostus,* precisely *hoiformis* and *hoi,* respectively in Eastern Asia and the B and D forms of *obesus* in Northern Europe, enable us to correlate approximately these two zones of the early Upper Cambrian age to the *Chuangia* zones of the Chaumitian.[1]

The A form of *obesus* is an intermediate link between *pater* and *Geragnostus.* In it the median preglabellar furrow begins to die out. Probably the C form of *obesus* is a *Geragnostus* from which the later geragnostids are developed through *rudis* and its variety in the medieval Upper Cambrian. The variety *holmi* differs from the typical form of *rudis* merely in the convexity of the pygidium and the size of the axis. BELT's *obtusus* is known only of the cephalon, but it is more suggestive of *Geragnostus* than *Agnostus* s. str., as it has no trace of the median preglabeller furrow. The outline of the cephalon is subquadrate in *obtusus,* whereas it is more rounded in *rudis.*

In the same region *rudis* is succeeded by *sidenbladhi, calvus, latemarginalis,* and *callavei* in the *Shumardia* zone, where *dux* appears simultaneously. *Callavei* was once referred to *Peronopsis* by RAYMOND,[2] but its very close affinity to *sidenbladhi* is against this suggestion. In LINNARSSON's *sidenbladhi,* the transverse furrow on the glabella is faint, the basal side-lobe very tiny, and the median tubercle discernible. These features distinguish this from *callavei.* *Calvus* differs from the two Trémadocian forms as well as the Upper Cambrian *rudis* by the large posterior lobe of the pygidial axis, while its variety, *latemarginalis,* has the axis of the pygidium tapering backward.

The same feature is observed also in HOWELL's *gallicus* from the Middle Tremadocian of South France, with the result that a better display of the genus from the Middle Tremadocian to the Arenigian

1) KOBAYASHI (1933), Op. cit.
2) RAYMOND (1924), Op. cit., p. 395.

(*Calymene* shale) was recently made by HOWELL. Among the French species, a particularly interesting one is that represented by *occitanus* in the Lower Arenig and *boutouryensis* and *languidus* in the *Calymene* shale, through which reduction of the surface relief is emphasized one after another. In the first species, as in *sidenbladhi*, the transverse furrow on the glabella is obsoleted; in the second the glabella is slightly elevated and its furrows are obscured; while in the third, the elevation and lobation of the pygidial axis is reduced. That the three forms, *languidus, boutouryensis*, and *subobesus*, have all very wide flanges on their pygidia is also remarkable.

Bavaricus[1] has no furrow on the pygidium. As suggested by POMPECKJ,[2] its affinity with the smooth *Geragnostus* is undeniable. *Agnostus splendens* HOLUB[3] from the Tremadocian of Bohemia might also be a *Geragnostus*, but a revisional study of these type specimens is required to decide their true generic position. MATTHEW's *bisectus* is the solitary representative of *Geragnostus* in the Canadian of eastern North America.

Outside of the Atlantic province this genus is not very common. RAYMOND's *insuetus*[4] from the Main zone of the Milton in Vermont is a *Geragnostus*. This zone is regarded as the Franconian stage of the Croixan in which *Agnostus trisectus*, an indicator of the *Peltura* bed of the Atlantic province, occurs. Then, in the late Upper Cambrian of the Yukon-Alaska boundary there is *subobesus*,[5] which is accompanied by *Parabolinella* (?) *punctolineata*. *Agnostus chiushuensis* in the Wanwanian is the only known species from the Western Pacific side.

In the course of this study two species were found in South America, the one in late Upper Cambrian and the other in Lower Ordovician. Besides, I presume that *Agnostus tilcuyensis*[6] might be a *Geragnostus*.

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1) J. BARRANDE (1868), Faune Silurienne des Environs de Hof, en Bavière, p. 82, figs. 46-47.

2) J. F. POMPECKJ (1901), Aus dem Tremadoc der Montagne Noire (Süd-Frankreich), (Neues Jahrb. f. Min. Jahrg. 1902, Bd. I,) p. 7.

3) HOLUB (1912), Op. cit., p. 2, fig. 4.

4) RAYMOND (1924), Op. cit., p. 393, pl. 12, figs. 2 & 6.

5) T. KOBAYASHI (1936) Cambrian and Lower Ordovician Trilobites from Northwestern Canada, (Joul. Pal. Vol. 10,) p. 161, pl. 21, figs. 1-2.

6) KAYSER (1876), Op. cit.

Geragnostus tullbergi, new species

Plate II, figures 3-4, 5 ?

Description:— Cephalon and pygidium rounded at anterior and posterior margin respectively, equally convex and surrounded by brims that narrow toward articulating margin; their axes considerably elevated above side-lobes.

In cephalon, brim convex, well defined by marginal groove; glabella subconical, wider than side-lobe, about as long as two-fifths of cephalon and more or less rounded at front; it is surrounded by deep groove and bilobed by distinct transverse furrow; median tubercle mostly very obscure; basal side-lobes tiny; articulating platform discernible.

In pygidium, border somewhat flat and considerably broadened behind; rear spines absent; axis divided into two short anterior and a long posterior lobe which, in length, approximates sum of anteriors; at anterior margin, it is as wide as side-lobe, but narrows abruptly, then parallel-sided or even contracted and rounded behind; circumaxial and first axial furrows strong, but second axial furrow and median tubercle weak.

Observation:— The outline of the shield varied among the specimens from Guanacuno. The original outline may be slightly longer than that of the cephalon in figs. 3 and shorter than that of the pygidium in fig. 4. The cephalon from Abra de Chorcoya in fig. 5 is the largest. The frontal lobe of the glabella is rather acutely rounded, but another found on the same slab is exactly the same as the cephalon in fig. 3 in both size and outline.

Comparison:— The distinct lobation and raised axis makes this species resemble the Upper Cambrian *calvus, insuetus* and *subobesus*, and the Lowest Ordovician *chiushuensis*, from which this is distinguished by the absence of the rear spines and the obscure median tubercles.

Formation and locality:— Late Upper Cambrian green or light yellowish sandstone. Guanacuno and Abra de Chorcoya.

Geragnostus quadratus, new species

Plate II, figures 6-7; Plate VII, figure 5

Description:— Cephalon subsquare, provided with narrow brim; side-lobe nearly flat in inner half and gladually sloping in outer;

glabella slightly elevated, conical, as wide as side-lobe at base, increasing its elevation backward; transverse furrow weak; median tubercle and basal side-lobes obscure. Pygidium subsquare and quite convex; axis occupies less than two-thirds length of pygidium, elevated, unequally trilobed; circum-axial furrow deep but lateral furrows short and shallow; median tubercle large and prominent.

Observation:—Two cephala and three pygidia are in hand, but all deformed secondarily in various degrees. The pygidium, in fig. 7, plate II, probably shows the original outline; another in fig. 5, plate VII, is somewhat laterally compressed so that the posterior outline is more rounded than it was. However the marginal brim is clearly shown in the latter specimen.

Comparison:—In its subsquare outline, faint transverse glabellar furrow, and relatively short and unequally divided axis of the pygidium, this is most allied to *sidenbladhi* of the Tremadoc, but it has no rear spines,

Formation and locality:—Basal Ordovician dark gray shale; Cuesta de Erquis, Tarija and Guanacuno.

Suborder MESONACIDA Swinnerton

Family KAINELLIDAE Ulrich and Resser

1930. *Kainellidae* Ulrich and Resser, Bull. Public Museum of the City of Milwakee, Vol. 12, No. 1, p. 62, (listed.)

1935. *Kainellidae* Kobayashi, Japan. Jour. Geol. Geogr. Vol. XII, p. 64.

1935. *Kainellidae* Kobayashi, Jour. Fac. Sci, Imp. Univ. Tokyo, Sect. II, Vol. IV, Pt. 2, p. 124, (discussed.)

Family diagnosis:—Zacanthoid-trilobites with large or medium-sized eyes close to the glabella and horizontal or widely divergent facial sutures anterior to the eyes on the cephalon, and pleural lobes produced into spines on the pygidium.

Remarks:—As discussed in my paper cited, the two eastern Pacific genera *Kainella* of the basal Ordovician and *Zacanthoides* of the early Middle Cambrian agree in so many respects that the latter is presumed to be the ancestor of the former. The long expanse of time between these occurrences should, however, be filled by some links.

Of fossils of the late Middle Cambrian, *Centropleura* first attracted my attention. It is certainly similar to *Kainella* in general aspects, notably in its anterior facial suture, falcate thoracic pleura, serrated pygidium, and so forth. But, as has been determined by long

research, the genus is a terminal member of the Paradoxidae in the Atlantic province that is parallel to the Zacanthoidae in the Pacific. *Centropleura* is distinct from *Kainella* in the nature of its glabella, palpebral lobe, and pygidium.

Apatokephaloides from the Upper Cambrian of Vermont is a genus that reminds me of the *Kainella* affinity. As discussed in a paper of mine, it is related to *Kainella* on the one hand and to *Corbinia* on the other. But *Kainella* resembles *Zacanthoides* far more than *Zacanthoides* does *Apatokephaloides*. The *Apatokephaloides-Corbinia* line is, therefore, probably an off-shoot from the main evolutional line of *Zacanthoides-Kainella* but not an actual link between them. Thus, for the fossil hunter of the future, the discovery of the missing link lies in the offing.

As to the Ordovician descendant genera, *Apatokephalus* and *Macropyge*, the former is, as its name suggests, allied to *Apatokephaloides* in the glabella and pygidium, but the agreement of the fan-shaped preglabellar area and the large eye-band suggests that it is certainly closer to *Kainella* than to *Apatokephaloides*, while its taxonomic position natually lies between *Kainella* and *Apatokephaloides*. *Apatokephalus* is probably the ancestor of the Remopleuridae, and is so considered by various authors, but to me it appears more likely that *Apatokephalus* belongs to the Kainellidae rather than to the Remopleuridae.

Another question concerning *Macropyge* is whether it can be a member of the Remopleuridae. When Stubblefield[1] established this genus, he brought *Lichas* (*Uralishas*) *riberoi* Delgado into comparison with it from

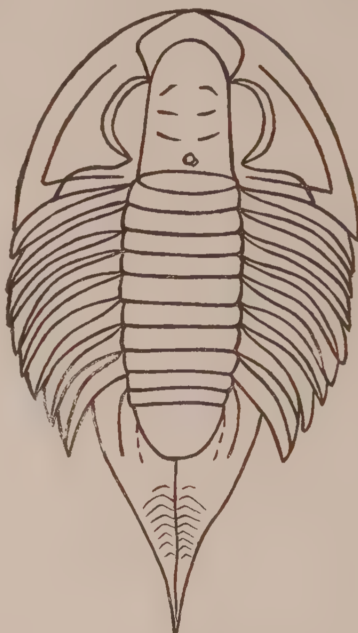


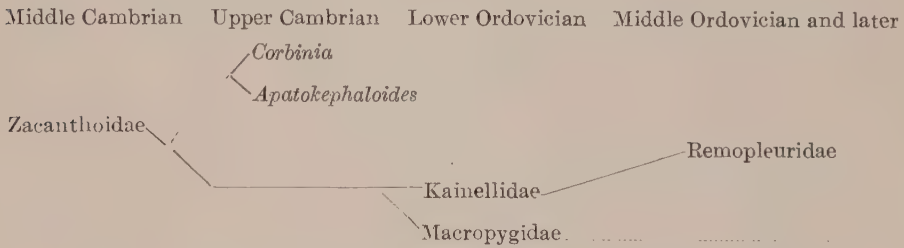
Fig. 19. *Macropyge chermi* Stubblefield

Fig. 20. *Lichapyge cuspidata* Callaway

1) C. J. Stubblefield and O. M. B. Bulman (1927), The Shineton Shales of the Wrekin District, (Quart. Jour. Geol Soc. London Vol. LXXXIII,) p. 140.

the aspect of the pygidium, but denied the existense of actual phylogenetical relations, basing his argument mainly on the configuration of the cephalon. After close examination of various characteristics, LAKE[1] concluded that *Macropyge* is not essentially distinct from *Apatokephalus, Robergia,* and *Remopleurides*. However, it can hardly be overlooked that the difference between *Macropyge* and the remopleurids exceeds far more than what obtains among remopleurids.

On the other hand, the nearest genus to *Macropyge* is *Lichapyge*. Our knowledge of *Lichapyge* is, of course, in complete, but so far as concerns the thoracic segments and pygidium, all of which are now known, *Lichapyge* and *Macropyge* may be combined as a small but solid group of trilobites, although at the same time this combination excludes *Lichapyge* from the Lichidae. The phylogenetical relationship among the genera discussed above may be demonstrated more clearly from the following chart:—



The conclusion at which I now arrive is that the Remopleuridae, as it used to be considered, is not a descendant of the Paradoxidae but of the Zacanthoidae, probably through the Kainellidae, and many derivatives of the Zacanthoidae stock may tentatively be bound up in the following manner:

1. Group of *Apatokephaloides* (Upper Cambrian)
   Apatokephaloides
   Corbinia
2. Kainellidae (Lower Ordovician)
   Kainella
   Apatokephalus
3. Macropygidae, new family (Lower Ordovician)
   Macropyge
   Lichapyge

1) P. LAKE (1931), A Monograph of the British Cambrian Trilobites, (Palaeontogr. Soc.) pp. 124–125.

4. Remopleuridae (Middle and Upper Ordovician)
   Remopleurides
   Teratorhynchus
   Robergia
   Caphyra

Finally, it may be added that *Apatokephalus* sp.[1] known from the Balclatchine group (Llandeilo) of Balclatchie, Girvan, is the latest representative of the genus. It is known only of the pygidium, which is subsquare in outline and whose posterior margin has unusually shallow serrations, is known.

Genus KAINELLA WALCOTT, 1924

1924. *Kainella* WALCOTT, Smiths. Misc. Coll. Vol. 75, No. 2, p 12.
1925. *Kainella* WALCOTT, Smiths. Misc. Coll. Vol. 75, No. 3, p. 100.
1935. *Kainella* KOBAYASHI, Japan. Jour. Geol. Geogr. Vol. XII, p. 64.

Genotype:—*Hungaia billingsi* WALCOTT.

Remarks:—Beside the above cited species, the following five have been described from the western side of North and South America:—

1. *Dicelocephalus* (?) *flagricaudus* WHITE (Nevada)
2. *Dikelocephalus inexpectans* WALCOTT (Nevada)
3. *Kainella meridionalis* KOBAYASHI (Prairie Catamarca, Argentina.)
4. *Kainella conica* KOBAYASHI (Prairie Catamarca)
5. *Kainella lata* KOBAYASHI (Prairie Catamarca)

We know the cranidium, free cheek, thoracic segments, and pygidium, all detached from one another, of *K. billingsi* and *K. meridionalis*; but only the cranidium of *K. inexpectans*, *K. conica*, and *K. lata*; and the pygidium of *K. flagricaudus*. The specific distinctions are mainly based upon the outline of the glabella, size of the palpebral lobes, and shape of the preglabellar area on the cranidium, and the outline of the pygidium itself and its axial lobe. In dealing with STEINMANN's collection it is very odd to find in such a remote place a form almost identifiable with *Kainella billingsi*. Besides this species, the collection contains *K. meridionalis*.

Geological and geographical Distribution:—Basal Ordovician; Bolivia and northwestern Argentina, and the Cordilleran trough from

1) F. R. COWPER REED. (1903), The Lower Palaeozoic Trilobites of the Girvan District, Ayrshire Pt. I, (Palaeontogr. Soc.) p. 30, Pl. IV, fig. 9.

Nevada to British Columbia in the West and from the Champlain Valley to Quebec in the eastern part of North America.

Kainella billingsi (WALCOTT)

Plate III figure 3; plate IV, figures 9–11

1912. *Cheirurus* sp. HOEK, Op. cit., p. 223, Pl. XI, fig. 9.
1913. *Hungaia billingsi* WALCOTT, Smiths. Misc. Coll. Vol. 57, No. 12, p. 336, (listed.)
1924. *Hungaia billingsi* WALCOTT, Smiths. Misc. Coll. Vol. 75, No. 1, p. 37, fig. 7.
1925. *Kainella billingsi* WALCOTT, Smiths. Misc. Coll. Vol. 75, No. 3, p. 102, pl. 22, figs. 1–7.

The specimens at hand are in a shale, and to a certain extent, secondarily deformed. The cranidium has a long cylindrical glabella provided with two pairs of oblique and strong pits; a relatively small, crescentic palpebral lobe is set close to the glabella; irregular ridges on the frontal limb terminate at a row of pits just inside the frontal rim; facial suture intramarginal on the frontal brim and transverse on the postero-lateral limb; free cheek of the same aspect as that of WALCOTT's form. The pygidium has a conical axis consisting of more than six rings and three pleural ribs produced back into the spines. These characteristics lead me to identify this Bolivian form with WALCOTT's species, although an acurate comparison might reveal some minor differences. In this Bolivian form the eye-band may be slightly larger and actually in contact with the glabella. In the holotype of the species (WALCOTT, Pl. 22, fig. 1,) the palpebral lobe is not well preserved, so that some question may still be raised regarding WALCOTT's restoration of this portion; the same being true of his pygidium, As restored by WALCOTT, the specimen has only two pairs of spines, and the posterior margin between the second pair is apparently entire (WALCOTT, 1924, p. 38, fig. 7), but this portion is broken off in his specimen (WALCOTT 1935, pl. 22, fig. 4), and in fact the third pleural rib is produced into a spine as the first and second, the feature being verified by this Bolivian form.

The difference in facial sutures might suggest the mutation. The sutures anterior to the eyes are diagonal in this Bolivian form, instead of transversal as in the British Columbian. But even this renders to the deformation to some extent, which is what has happened to this Bolivian form.

Finally, the associated pygidium illustrated in fig. 1, pl. VI, is a reproduction from the original specimen described as *Cheirurus* sp. by HOEK, which is nothing but a pygidium of *K. billingsi* itself.

Formation and locality:—Dark grey-coloured *Kainella* shale of Cuesta de Erquis, Tarija and east of Obispo; Chushina of British Columbia.

Kainella meridionalis KOBAYASHI

Plate IV, figures 6–8

1912. *Megalaspis americana* HOEK, Op. cit., p. 220, Pl. X, figs. 2–3 only.
1935. *Kainella meridionalis* KOBAYASHI, p. 64. Pl. I, figs. 2–10.

A restudy of the original cranidium of HOEK made it clear that *Megalaspis americana* is a compound species including this one and an asaphid, to the latter of which his specific name will hereafter be confined. Fig. 7, pl. VI, is a reproduction from this type, the matrix behind the cranidium having been cleaned out. That the cranidium is identical with the present species is manifest at a glance, although his specimens are much larger than those described from Argentina.

A pygidium in this Bolivian collection fortunately shows the outline completely, from which I gather that the axial lobe is really much wider and more conical than what I had formerly presumed. A sharp bend of the axial ring at the median point is clearly shown and a re-examination of the Argentine pygidium shows the same aspect. The only difference between the two pygidia lies in the length of the first pair of posterior spines, which are a little shorter in the Bolivian than in the Argentine.

A comparison of this species with *K. inexpectans*, to which it is most closely allied, was made in my previous paper.

Formation and locality:—The *Kainella* gray sandstone of Abra de Chorcoya[1] and Prairie Catamarca, and the *Kainella* grey shale of Cuesta de Calama and Guanacuno.

Family Macropygidae, new family

Family diagnosis:—Zacanthoid-trilobites with large eyes close to

1) The original label reads "Aquas Calientes, Quebrada de Reijes (Jujuy)".

the glabella, intramarginal facial sutures on the cephalon and an entire margin of the pygidium except for a prolonged posterior tongue.

Geological and geographical distribution:—Tremadocian of Northern and Central Europe.

Genus MACROPYGE STUBBLEFIELD, 1927

1927. *Macropyge* STUBBLEFIELD and BULMAN, Quart. Jour. Geol. Soc. London, LXXXIII, p. 140.
1931. *Macropyge* LAKE, A Monograph of the British Cambrian Trilobites, p. 124.

Genotype:—*Macropyge chermi* STUBBLEFIELD.

Genus LICHAPYGE CALLAWAY, 1877

1874. *Lichapyge* CALLAWAY, Q. J. G. S. London, XXX, p. 196, (nom. nud.)
1877. *Lichapyge* CALLAWAY, Q. J. G. S. London XXXIII, p. 667.

Genotype:—*Lichapyge cuspidata* CALLAWAY.

Remarks:—Besides the genotype, *Lichapyge primulus* BARRANDE[1] belongs here. *Lichapyge problematica* REED[2] is, as discussed elsewhere,[3] more likely a Dikelocephalidae.

A minute pygidium from the Ashigillian of Montgomeryshire is referred to *Lichas geikiei* var. by KING,[4] but probably distinct from ETHERIDGE'S and NICHOLSON'S species. From its outline, and the cylindrical axis produced into a narrow ridge and two pairs of furrowed anterior pleurae, I think that this pygidium may not belong to a derivative of *Lichapyge*. I, however, hesitate to refer it to *Lichapyge* not only because of the occurrence in such a high horizon, but because of a narrow posterior sinuation.

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1) J. BARRANDE, (1868), Faune Silurienne des Evirons de Hof, en Baviere. p. 86, figs. 34.

2) F. R. COWPER REED (1906) Lower Palaeozoic Trilobites of the Girvan District, Ayrshire, Pt. III, p. 110, pl. XV, figs. 8–10.

3) T. KOBAYASHI, (1936) Three Contributions to the Cambro-Ordovician Faunas, I. The Dikelokephalininae (nov.), its Distribution, Migration and Evolution, (Japan. Jour. Geol. Geogr. Vol. XIII.)

4) W. B. R. KING (1923), The Upper Ordovician Rocks of the South-western Berwyn Hills, (Q. J. G. S. London, Vol. XXIX,) p. 505, pl. XXVI, fig. 3.

Family Cheiruridae SALTER

Genus PROTOPLIOMEROPS KOBAYASHI, 1935

Protopliomerops punctulifera, new species

Plate VI, figures 4-5

1912. *Pliomera* (?) sp. HOEK, Op. cit., p. 2237, pl. XL, fig. 1.

Description:—Cephalon semi-circular and gently convex; glabella long, subquadrate, slightly tapering forward, more or less rounded in front; three pairs of glabellar furrows oblique, disconnected in middle; occipital furrow and lobe transverse; eyes anterior, opposite first glabellar furrows and slightly oblique; fixed cheek as wide as glabella; no frontal limb; marginal brim strong; genal spine of moderate length; facial suture cuts lateral margin far anterior to genal angle; surface marked by irregular and prolonged pits.

Pygidium exclusive of spine subtriangular; axis elevated, wider than pleural lobe, conical, narrowing backward regularly and divided into five ridges and a terminal triangular lobe; pleural lobe divided into about five ribs, each one being produced into a relatively long spine.

Comparison:—The pygidium which I have here is an internal mould, its margin being marked by a deep groove through which the ribs and spines are disconnected. This aspect is similar to a ventral view of *Protopliomerops seisonensis*.[1]

The difference between this species and *P. seisonensis* is in the outline of the glabella, weak glabellar furrows, relatively transverse eye-lobes, longer fixed cheek and the texture of the test on the cephalon. In the pygidium the two species are quite similar, but the axial lobe is broader in this one.

Formation and locality:—Basal Ordovician of Cuesta de Erquis, Tarija, Bolivia.

Suborder PTYCHOPARIDA RICHTER

Family Ellipsocephalidae MATTHEW

Subfamily Kingstoninae KOBAYASHI

Genus PLETHOPELTIS RAYMOND, 1913

Plethopeltis megalops, new species

Plate III, figures 8-10

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1) T. KOBAYASHI (1935), Jour. Fac. Sci., Imp. Univ. Tokyo, Sect. II, Vol. III, Pt. 9, p. 571, pl. VII.

1912. *Conocephalites* aff. *striatus* HOEK, Op. cit., p. 221, Pl. IV, fig. 10-15, cranidium and free cheek only.
1912. *Arionellus* sp. HOEK, Op. cit., p. 210.

The subquadrate glabella with two pairs of feeble glabellar furrows, narrow fixed cheek, rather anterior eyes, convex preglabellar area without brim and neck-ring wide in the middle, are typical of *Plethopeltis*. In comparing this with a species of *Plethopeltis* known from Eastern Asia and North America, the gentle tapering of the glabella and very long genal spine are distinguishing specific characteristics. HOEK presumed that the cranidium of this species had a brim, but I failed to find it. So far as this cephalon is concerned, it is hardly referable to species of any genus of the Ptychoparidae. The thoracic segment referred to this species by HOEK is, on the other hand, typical of the Olenidae, and most probably belongs to *Jujuyaspis steinmanni* found in the same slab. A laterally compressed cranidium of HOEK's *Arionellus* sp. (fig. 10, pl. III,) from Pampa de Tascara, between Tojo and Tarija is, so far as I can see, identifiable with this species.

Formation and locality:—Late Upper Cambrian green sandstone, Guanacuno, Bolivia and Pampa de Tascara.

Genus PLETHOMETOPUS ULRICH, 1931

Plethometopus micropthalmus, new species

Plate III, figures; 12-14; plate VII, figure 7

This is similar to *Plethopeltis megalops*, but the eye are small and much more anterior; the glabellar and occipital furrows are obsolete and the genal spine is short. This cephalon is roundly subquadrate and gently convex, the truncato-conical glebella above the cheeks and the frontal brim, although indistinct, are still discernible. This resembles *Plethometopus laevis* (RAYMOND)[1] from zone 3 of the Milton formation in Vermont, but in that species the eye is not so anterior, the glabella is subquadrate and more obscurely outlined. It moreover has no frontal brim.

The most allied species may be *Andesaspis argentinus*,[2] from which, however, this can be distinguished by the less convex glabella with a rather straight frontal margin.

Formation and locality:—Light green sandstone of Guanacuno,

1) P. E. RAYMOND (1924), New Upper Cambrian and Lower Ordovician Trilobites. (Proc. Boston Soc. Nat. Hist. Vol. 37, No. 4,) p. 417, pl. 13, fig. 3.
2) KOBAYASHI (1935), Japan, Jour. Geol. Geog. Vol. XII, p. 67, pl. XI, figs. 1-4.

Escayache-Kette, associated with asaphid cephala and pygidia.

Family Olenidae Burmeister
Subfamily Oleninae Kobayashi
"Genus OLENUS Dalman, 1827
"Olenus" argentinus (Kayser)

Plate IV, figures 6-9; text-figure 6

1876. *Olenus argentinus* Kayser, Op. cit., p. 6, pl. I, figs.-3.
1912. *Olenus* cfr. *argentinus* Hoek, Op. cit., p. 209, Pl. VII, fig. 10.
1936. *Olenus* (?) *argentinus* Kobayashi, Japan. Jour. Geol. Geogr. Vol. XIII, p. 95.

Description:—Glabella convex, elevated above cheeks, long, slowly tapering forward and rounded in front; first and second pairs of glabellar furrows oblique and interrupted on axis; third and occipital furrows run across the glabella; eyes medium-sized and at about mid-length of cranidium and united with glabella by oblique eye-ridge; fixed cheek across eyes as wide as half the breadth of glabella; frontal limb narrow; marginal brim convex, elevated and produced into genal spine at lateral extremity; facial suture subparallel, anterior to eyes and diagonal posterior to them.

Observation:—Only the cranidium and free cheek of the species are known. From the long glabella reaching the brim, as illustrated by Hoek, I first questioned its close resemblance to Kayser's species. However, with the specimen before me I now see that Hoek's illustration is incorrect and that the glabellar length just approximates that of Kayser's.

Comparison:—So far as I can make out from Kayser's description and illustration, this identification appears to be certain. A general olenid-aspect is recognized from these observations, but this is certainly not an *Olenus* s. str. The nearest genus in the Olenidae is probably *Parabolina*, from which it is distinguished by its relatively posterior eyes, oblique palpebral ridge and narrow fixed cheek. Kayser compared this species with *Loganellus*, but in *Loganellus* the facial sutures are widely divergent anterior to the eyes, and the glabellar furrows not united.

Another genus allied to it is *Crepicephalus*, as has already been suggested by Hoek. For example, *Crepicephalus upis* Walcott,[1] which

1) C. D. Walcott (1916), Smiths. Misc. Coll. Vol. 64, No. 3, p. 218, pl. 33, fig. 4, 4a-b.

was recently referred to *Kochaspis* by RESSER,[1] shows quite a resemblance, but in *Crepicephalus* the glabella is more conical than in this species, and the third pair of glabellar furrows are again not united. The outstanding distinction between the Olenidae and Crepicephalidae is in the nature of the pygidium, to the discovery of which the final solution is due, but as far as the cephalon is concerned, the species appears close to *Parabolina*.

Formation and locality:—Upper Cambrian sandstone; west side of Abra de Escayache.

Olenus (?) sp.

Plate IV, figure 14

This is found in association with *Parabolinella andina*, it is distinguished from the latter by its broad, non-crenulated outline. It resembles *Olenus transversus* LINNARSSON,[2] but its pygidium is more transversely elongated and the axial ring of the thorax has a median tubercle. In these respects it agrees with *Parabolinella laticauda* WESTERGÅRD,[3] although the axis of this pygidium is more conical than that of *P. laticauda*.

Formation and locality:—Late Upper Cambrian black slate; Salitre, Bolivia.

Genus PARABOLINA SALTER, 1849

1849. *Parabolina* SALTER, Mem. Geol. Surv. United. Kingd. Dec. II, Pl. 9, p. 2.
1878. *Parabolina* ANGELIN, Pal. Scandinavica, 3d. ed. Holmiae, p. 45.
1896. *Parabolina* KOKEN, Die Leitfossilien, Leipzig, p. 20, text-fig. 11, fig. 11.
1898. *Parabolina* MOBERG & MÖLLER, Geol. Foren Stockholm Forhandl. XX, p. 229.
1901. *Parabolina* LINDSTRÖM, Kongl. Sven. Vet. Akad. Hand. XXXIV, No. 8, p. 19, 22.
1904. *Parabolina* PERSSON, Geol. Foreh. Stockholm, Forhandl. Bd. 26, Heft. 7, p. 525.
1908. *Parabolina* LAKE, Monogr. Brit. Camb. Tril. Pt. 3, Pal. Soc. p. 61.
1910. *Parabolina* GRABAU and SHIMER N. A. Index Fossils vol. 2, p. 279.
1935. *Parabolina* KOBAYASHI, Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. II, Vol. IV, No. 2, p. 257.

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1) C. E. RESSER (1935), Nomenclature of Some Cambrian Trilobites, (Smiths. Misc. Coll. Vol. 93, No. 5.)

2) A. H. WESTERGÅRD (1922), Sveriges Olenidskiffer, (Sveriges Geologiska Undersökning Ser. Ca, Nio 18,) p. 195, pl. III, figs. 11-17.

3) WESTERGÅRD (1922), Op. cit., p. 198, pl. VIII, figs. 1-7.

Genotype:—*Entomostracites spinulosus* WAHLENBERG.

Remarks:—This is a very spinose Olenidae. Its major generic characteristics are a long cylindrical glabella more or less rounded in front, narrow frontal limb, prominent ocular ridge, small anterior eyes, thoracic pleura terminating at a spine and a pygidium with spines. On complete specimens, twelve thoracic segments are to be counted; a median tubercle is also frequently seen on the axial ring of each segment.

In Scandinavia[1] the following eight species are known, distributed from the *Parabolina spinulosa* zone to the top of the Upper Cambrian.

Parabolina acantura (ANGELIN)
Parabolina brevispina WESTERGÅRD
Parabolina heres BRÖGGER
Parabolina jemtlandica WESTERGÅRD
Parabolina longicornis WESTERÅGRD
Parabolina megalops MOBERG & MÖLLER
Parabolina mobergi WESTERGÅRD
Parabolina spinulosa (WAHLENBERG)

Parabolinella spinulosa of the Upper *Lingula* Flag in England is the only species described in LAKE's monograph.[2] *Olenus* (*Parabolina*) *serratus* SALTER was identified with *P. spinulosa* by SALTER[3] himself.

The Bretonian of New Brunswick and Nova Scotia[4] yields the following species:—

1. *Parabolina dawsoni* MATTHEW
2. *Parabolina grandis* var. *heres* MATTHEW
3. *Parabolina heres* var. *lata* MATTHEW
4. *Parabolina spinulosa* (WAHLENBERG)

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1) A. H. WESTERGÅRD (1922), Sveriges Olenidskiffer, (Sveriges Geologiska Undersökning Ser. Ca, Nio 18.)
L. STÖRMER (1934), Cambro-Silurian Zones of the Oslo Region, with a brief Correlation between the British and Norwegian Sections. (The Geology of Parts of Southern Norway, the Geologist Association, London,) p. 26.

2) P. LAKE (1908), A Monograph of the British Cambrian Trilobites, Pt. III, (Paleont. Soc.)

3) J. W. SALTER (1873), A Catalogue of the Collection of Cambrian and Silurian Fossils, p. 11.

4) G. F. MATTHEW (1892), Trans. Royal. Soc. Canada, 9 Ser. 4.
G. F. MATTHEW (1903) Report of the Cambrian Rocks of Cape Breton, (Geol. Surv. Canada.)

As discussed in the succeding pages, *Parabolinella andina* HOEK of South America is certainly a *Parabolina*.

Parabolina andina (HOEK)

Plate IV, figures 10-13; Plate VIII, figure 3

1912, *Parabolinella andina* HOEK, Op. cit., p. 214, pl. VII, figs. 7-9.

Observation:—A detailed description of this has already been given in the papers cited. In the pygidium illustrated in fig. 9, pl. VII by HOEK, the first segment is not actually fused with the rest, so that it is not a part of the pygidium, but the twelfth thoracic segment with a long telson. The margin of the pygidium is not entire, as is illustrated by HOEK, but has four pairs of serrations. The same figure by HOEK shows that the telson is produced back from the axis of the pygidium. In reality, however, the telson originating from the twelfth thoracic axis lies on the axis of the pygidium so that it presents just such an aspect.

Comparison:—HOEK referred this species to *Parabolinella*. As stated by LAKE,[1] *Parabolinella* is indeed more allied to *Olenus* than *Parabolina*. The main distinctions between *Olenus* and *Parabolinella* are the anterior facial sutures, which are divergent in the latter, but neither of them are as spiny as *Parabolina*. In the adult stage the number of thoracic segments is 12 in *Parabolina*, and 13 to 15 in *Olenus*, but no less than 14 in *Parabolinella*. Not only in these respects, but also in the rounded glabella, narrow frontal limb, tuberculated axis of the thorax, and other characteristics, this is diagnostic of *Parabolina*.

Specifically, however, this is well qualified by its semi-oval glabella with two somewhat V-shaped grooves, relatively large and posterior eyes, long spines of thoracic pleurae, longest at the eighth one, and a long telson on the twelfth axial ring of the thorax, and serrated pygidium.

Hypostoma:—An associated hypostoma is subovate, with a pair of narrow antero-lateral wings; the central body convex, subelliptical and is elevated above the flat margin.

Formation and locality:—Late Upper Cambrian black slate; Salitre, Bolivia.

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1) P. LAKE (1908), Op. cit.

Parabolina sp. indt.

Plate III, figures 4-5

A small subtrapezoidal cranidium with a cylindrical glabella; occipital furrow distinct; neck-ring wide in the middle; eyes small, anterior, and close to the glabella; frontal brim transverse, narrow, and well-marked by a groove; facial sutures subparallel anterior to the eyes, and diagonal posterior to them. The glabella has at least two pairs of glabellar furrows. Besides the cranidium, a fragment of thorax with a wide axis is found on the slab. Both are tiny; the cranidium is only about 1. 3 mm. long, hence it is quite possibly an immature form. Its exact generic determination is well nigh impossible. It must belong to the Oleninae, or probably to *Parabolina*.

Formation and locality:—This inclusion of the Olenidae member in the *Kainella* fauna at Obispo is, however, in itself, worth recording.

Genus PARABOLINELLA Brögger, 1882

Parabolinella (?) aff. *shinetonensis* Raw

Plate IV, figures 18–19

Two incomplete specimens of a *Parabolinella* (?) sp. are found associated with *Parabolinopsis mariana* in the same slab. One (fig. 18, pl. V,) has a quadrate glabella with two pairs of long and oblique glabellar furrows and eleven thoracic segments; the rear part behind the eleventh is not preserved. Another specimen (fig. 19, pl. IV) shows the hind part of the carapace, composed of a broad pygidium and ultimate and penultimate thoracic segments. The latter has a long telson.

It is certainly similar to *Parabolina andina*, but differs in the outline of the glabella, which is rather expanded forward, instead of tapering forward in *P. andina*. Furthermore, its glabellar furrows are not united at the middle as in the case of that species. *Parabolinella argentinensis*[1] is another one that resembles it, but the former has no thoracic segment with telson. The most allied species would be

1) T. Kobayashi (1936) On the *Parabolinella* Fauna from Province Jujuy, Argentina with a Note on the Olenidae, (Japan. Jour. Geol. Geogr. Vol. 13.)

Triarthrus (?) *shinetonensis* RAW,[1] but the poor state of preservation precludes identification.

Formation and locality:—White *Parabolinopsis* slate; Cuesta de Escayache, near San Lorenz.

Genus PARABOLINOPSIS HOEK, 1912

Parabolinopsis mariana HOEK

Plate IV, figures 15–17

1912. *Parabolinopsis mariana* HOEK, Op. cit., p. 226, pl. VII, figs. 1–3.

The significant characteristics of this trilobite are a smooth subquadrate glabella, anterior small eyes close to the glabella and truncated extremity of the thoracic pleura. The last mentioned characteristic has already been pointed out by HOEK, which appears very likely. This is really a significant feature of the Olenidae. The pleura is as long as the axial ring and is crossed by a diagonal pleural groove, and its lateral end appears to be truncated almost rectangularly. On this specimen thirteen thoracic segments are actually counted and two more axial rings (?) are seen behind them.

In HOEK's illustration the posterior branch of the facial suture on the right side of the observer is missing, but on the specimen it is seen rather distinctly.

Formation and locality:—White *Parabolinopsis* slate; Cuesta de Escayache, near San Lorenz.

Genus ANGELINA SALTER, 1864

Angelina punctolineata, new species

Plate VI, figure 22

Description:—Cranidium flat; glabella in the same niveau as the free cheeks, almost parallel-sided and truncated in front; except for occipital, no furrows on glabella, and even this is not strong; circum-glabellar furrow narrow but deep; fixed cheek quite narrow; eyes medium-sized and located at mid-length of cranidium; frontal rim much narrower than frontal limb, triangular, pointed at median point; row of pits seen along inner margin of frontal rim; facial suture

1) P. LAKE (1913), A Monograph of the British Cambrian Trilobites, Pt. IV, p. 70, Pl. VII, figs. 13–16.

slightly oblique in front of eye and joining its fellow at median point on frontal margin and highly oblique posterior to eye; surface smooth.

Comparison:—The single cranidium at hand is small and more or less compressed laterally. This is quite similar to *Angelina sedgwicki* SALTER, but distinguished by its large eyes and subsquare outline of the glabella. Except for an undescribed species from Skane in Sweden,[1] *Angelina sedgwicki* from the British Isles is the only species known. Therefore, this discovery in Bolivia is in itself quite significant.

Formation and locality:—Dark gray coloured *Kainella* shale; Cuesta de Erquis, Tarija, Bolivia.

Subfamily Leptoplastinae ANGELIN

Genus JUJUYASPIS KOBAYASHI, 1936

1936. *Jujuyaspis* KOBAYASHI, Japan. Jour. Geol. Geogr. Vol. XIII, p. 89.
1936. *Jujuyaspis* KOBAYASHI, Proc. Imp. Acad. Vol. 12, pp. 176–177.

Genotype:—*Jujuyaspis keideli* KOBAYASHI.

Remarks:—When I established this genus, I noticed that it was distinctly marked by its Proparia-like facial suture, but owing to the absence of the genal spine it was then impossible to decide whether it was a Proparian in BEECHER's original sense or not. *J. steinmanni*, however, has a genal spine on its fixed cheek, whence it may now be concluded that the former alternative is correct. As has already been discussed in a paper of mine,[2] the discovery of Proparian Olenidae indicates the polyphyletic origin of BEECHER's Proparia.

Jujuyaspis steinmanni KOBAYASHI

Plate V, figures 1–5

1936. *Jujuyaspis steinmanni* KOBAYASHI, Proc. Imp. Acad. Vol. 12, pp. 176–177, text-figs. 1–5.

The cranidium, free cheek, thoracic segment, and pygidium are all known, but detached from one another. All these parts of the carapace show marvellous resemblance with *Jujuyaspis keideli*, except for the following differences:

1) P. LAKE (1919), Monogr. of Brit. Cambr. Trilobites, Pt. V, p. 111.
2) KOBAYASHI (1935), Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. II, Vol. IV, Pt. 2.

1) The glabella is narrower in this species than in *J. keideli*, and the anterior margin of the cephalon more or less sinuated in *J. keideli*, whereas it is straight in this one.

2) The position of the eye is more anterior in *J. steinmanni* than in *J. keideli*.

3) The facial suture behind the eye is rather oblique in *J. steinmanni*, whereas it is almost transversal in *J. keideli*.

4) The fixed cheek of *J. steinmanni* has a genal spine.

With regard to the broad axis, oblique pleural furrows, and other aspects, the thoracic segment referred to *Conocephalites* cfr. *striatus* by HOEK might belongs to the Olenidae, and may not differ much from that of *J. steinmanni*. With the pygidium alone, distinction is hardly possible between *J. steinmanni* and *J. keideli*.

Formation and locality:—Late Upper Cambrian green sandstone; Guanacuno, Bolivia.

Family Shumaridae LAKE

Genus SHUMARDIA BILLINGS, 1865

1907. *Shumardia* LAKE, Monogr. British Cambr. Trilobites, Pt. II, (Palaeont. Soc.,) p. 40.
1924. *Shumardia* ZITTEL-BROILI, Grundzüge der Paleont. I, p. 647.
1926. *Shumardia* STUBBLEFIELD, Linn. Society's Jour. Zool. Vol. XXXVI, pp. 345–372, pls. 14–16.
1935. *Shumardia* KOBAYASHI, Jour. Foc. Sci. Imp. Univ. Tokyo, Sect. II, Vol. IV, Pt. 2, p. 211.
1931. *Shumardia* KOBAYASHI, Japan, Jour. Geol. Geogr. Vol. XI, p. 99, p. 211.

Genotype:—*Shumardia granulosa* BILLINGS.

Remark:—A historical review of the genus has already been presented in LAKE's paper; the ontogeny of *Shumardia pusilla* in STUBBLEFIELD's paper; and the distinction between the genera in the Shumardidae, in my own.

In my search for literature on the subject, I succeeded in finding 12 species and 1 variety of *Shumardia* as follows:—

Shumardia bottnica WIMAN (Tremadocian of Scandinavia)

Shumardia dicksoni MOBERG (Tremadocian of Scandinavia)

Shumardia granulosa BILLINGS (Canadian of Quebec)

Shumardia gracialis BILLINGS (Middle Ordovician (Normanskill) of Newfoundland)

Shumardia miqueli POMPECKJ (Tremadocian of South France)
Shumardia nericiensis WIMAN (Tremadocian of Sweden)
Shumardia ölandica MOBERG (Tremadocian of Scandinavia)
Shumardia (*Battus*) *pusilla* (SARS) (Tremadocian of Scandinavia, England, and Quebec in Canada)
Shumardia pusilla var. *morrensis* LAKE (Tremadocian of England)
Shumardia (*Conophyris*) *salopiensis* (CALLAWAY) by POMPECKJ (Tremadocian of England)
Shumardia pellizzarii KOBAYASHI (Tomkolian of South Chosen)
Shumardia scotica REED (Whitehouse Group (Middle Bala) of Girvan Scotland)
Shumardia orientalis MANSUY (Upper Cambrian of Indochina)

Shumardia gracilis was selected for the type species of *Anisonotus* in the Endymionidae by RAYMOND;[1] *Conophyris salopiensis* was considered a synonym of *Shumardia pusilla* by LAKE.[2] Putting aside the two species and judging from the outline of the pygidium, there are two groups to be distinguished. The one, or *granulosa* group, has a subtriangular pygidium, and the other, or *pusilla* group, a semi-elliptical pygidium, wider than long; the former is composed of *S. dicksoni*, *S. granulosa* and *S. orientalis*; the latter of *S. bottnica*, *S. miqueli*, *S. nericiensis*, *S. ölandica*, *S. pusilla* and *S. pusilla morrensis*.

Shumardia pellizzarii and *S. scotica*, being represented only by cranidia, the question to which group they belong cannot definitely be answered, although they are certainly *Shumardias*. *Shumardia* has been regarded as an indicator of the Tremadocian. It is certainly not confined to the Tremadocian, but ranges from the Upper Cambrian to the Caradocian and probably still later. The cephalon of the first species has a long nuchal spine, and its glabella appears to have characteristics distinct from the later forms. The second is represented by the pygidium alone. If they are both *Shumardias*, they certainly belong to the *granulosa* section. The Upper Cambrian ones have so far been confined to Eastern and Southeastern Asia.

Beside *Shumardia* two Upper Cambrian genera, *Idiomesus* and *Koldinioidia*, are included in the Shumardidae. The former is represented by the cephalon alone and the latter by the cephalon and pygidium which in turn is triangular in outline, in which respect it

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1) P. E. RAYMOND (1920), Some New Ordovician Trilobites, (Bull. Mus. Comp. Zool. at Harvard Coll. vol. LXIV, No. 2,) p. 279.
2) P. LAKE (1907), Monogra. British Cambr. Trilobites, Pt. 2, p. 42.

agrees with the pygidium of the Upper Cambrian *Shumardia.*

Thus, *Shumardia* which presumably arose in the western Pacific, enjoyed a wide distribution in the old and new worlds as well as in the northern and southern hemispheres in the Tremadocian. Subsequently, it died out, leaving a relic species in the Caradocian, in Scotland.

Shumardia erquensis, new species.

Plate VI, figures 1–3

1936. *Shumardia* cfr. *dicksoni*, Kobayashi, Japan. Jour. Geol. Geogr. Vol. 13, p. 87, (listed).

When studying Brown's collections from the Lower Ordovician of Argentina, I was impressed with the resemblance of this *Shumardia* cephalon to *Shumardia dicksoni.* In Steinmann's collection from Bolivia I found the same species. The associated pygidium found in this collection is, however, cleary distinct from *S. dicksoni,* and certainly belongs to the *pusilla* section. The outline of the pygidium is transversal and more or less sinuated at the rear; the axial and pleural lobes are segmented into three parts, and the intrapleural groove is rather distinct and oblique. The cephalon is convex and bent down along the marginal glabella, marked off by a deep and distinct circum-glabellar furrow; the frontal lobe expanded, behind which the glabella is cylindrical, provided by two pairs of horizontal glabellar furrows of moderate strength; the occipital groove is deep on the axial part, but fades out laterally. No granules are on the test.

Comparison:—This species is much closer to *S. pusilla* and *S. miqueli* than to *S. bottanica, S. nericiensis,* and *S. œlandica.* Since the test is smooth, it is easily distinguished from *S. pusilla. S. miqueli* is the most allied one from which this is still distinct, by virtue of its stronger glabellar furrows, thicker occipital lobe on the cheek, and oblique intrapleural furrow on the pleurae of the pygidium.

Formation and locality:—Dark coloured *Kainella* shale of Cuesta de Erquis, Tarija, Bolivia; *Leiostegium* limestone of Cajas, 15 miles west of Hambacca, Argentina.

Family Ptychoparidae Matthew

Subfamily Ptychoparinae Matthew

Genus PTYCHOPARIA Corda, 1847

"*Ptychoparia*" sp.

Plate IV, figure 20

1912. *Conocephalites* aff. *striatus* Hoek, Op. cit., Pl. VII, fig. 4, pygidium only.

In general outline this pygidium is certainly allied to that of *Ptychoparia striata* (Emmrich), namely similarities are recognized in the elevated axis above the gently inclined pleurae, the wide and flat pleural ribs defined by the narrow but deep groove and narrow ill-defined border. It differs from the pygidium of *P. striata* in its rather distinctly truncated posterior margin and the number of segments, which are seven on the axis and five on the pleural lobe, instead of ten and seven respectively in the other species.

In the Middle Cambrian this kind of pygidium is not uncommon. Besides *Ptychoparia* s. str. *Mapania* and *Elrathia* show similar characteristics, but I know of no like ones in the Upper Cambrian. The associated trilobites are *Geragnostus tullbergi*, *Jujuyaspis steinmanni*, *Plethopeltis boliviensis*, *Parabolinella* (?) sp. indt., and *Angelina* (?) sp. indt. Hence the Upper Cambrian age (or Lowest Ordovician) of the fauna is definite.

Unless other parts of the carapace are brought to light, generic determination of the species is hardly possible. Were any detached cephalon of these trilobites united with this pygidium, the chances are that they will be in the last three species, and were either one of the three combined with this pygidium, the aquired form will be a new one in the science of palaeontology.

Formation and locality:—Upper Cambrian green sandstone; Guanacuno, Bolivia.

Family Calymenidae Brongniart

Brief Historical Review:—Beecher[1] combined two groups of *Calymene* and *Homalonotus* into this family and placed it in Proparia.

1) C. Beecher (1897), Outline of a Natural Classification of the Trilobites, (Am. Jour. Sci. Ser. 4, Vol. 3.)

Subsequently, POMPECKJ[1] traced the *Calymene* line to *Bavariella* through *Pharostoma* and the *Homalonotus* line to *Neseuretus*, but the two lines are regarded as divisible into two distinct families, Calymenidae (s. str.) and Homalonotidae (nov.), this opinion being accepted by GÜRICH,[2] who has, however, established Gonatoparia (nov.) for them.

RAYMOND[3] followed BEECHER in placing the Calymenidae (s. 1.) in Proparia, because "not only the post-ocular portions of the facial sutures cut the genal angles in *Pharostoma*, the genal spines were borne by the fixed cheeks and free cheeks were decidely Proparian, but the cheeks in the earlier stage of the development of the common *Calymene senaria* of the American Trenton are also distinctly Proparian."[4]

WARBURG[5] on the other hand states that in "*Calymene* (*Pharostoma*) *pulchra* BARR. the spines are borne on the free cheeks which are also distinctly to be seen on his and CORDA's figures, and SCHMIDT has defined *Pharostoma* as having the posterior branches of the facial sutures cutting the border within the spines."

SWINNERTON[6] was of the opinion that the Calymenidae and Homalonotidae came from the *Ptychoparia* stock and belong to Opisthoparia, and this is supported by POULSEN[7] and RICHTER,[8] with a substitution by the latter author that the Menomonidae has branched off from the common stock between the two families.

Putting aside the *Homalonotus* series, the following genera are found to have been referred to the Calymenidae by various authors, (the genotypes are cited in brackets):

Calymene BRONGNIART, 1822 (*Trilobus tuberculatus* BRONN)
Pharostoma CORDA, 1847 (*Calymene pulchra* BARRANDE)
Prionocheilus ROUAULT, 1847 (*Prionocheilus verneuili* ROUAULT)
Bavariella BARRANDE, 1869 (*Bavariella hofensis* BARRANDE)

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1) J. F. POMPECKJ (1898), Ueber *Calymene* BRONGNIART, (Neues Jahrb. Jahrg. 1898, Bd. I.)

2) G. GÜRICH (1908), Leitfossilien, I. Kambrium und Silur, p. 70.

3) P. E. RAYMOND (1913), in ZITTEL-EASTMANN's Text-book of Palaeontology, I.

4) P. E. RAYMOND (1917), BEECHER's Classification of Trilobites after twenty Years, (Am. Jour. Sci. Vol. XIII.)

5) E. WARBURG (1925), The Trilobites of the *Leptaena*-Limestone in Dalarne, (Bull. Geol. Inst. Upsala, Vol. XVII,) p. 68.

6) H. H. SWINNERTON (1915), Suggestions for a revised Classification of Trilobites, (Geol. Mag, New Ser. Dec. VI, Vol. 2,) p. 494.

7) C. POULSEN (1927), The Cambrian, Ozarkian and Canadian Faunas of Northwest Greenland, (Jubiliaemuseksspeditionen Nord om Grønland, 1920-23, Nr. 2.)

8) R. RICHTER (1931), in Handwörterbuch d. Naturwissenschaften, 2te Aufl.

Neseuretus HICKS, 1872 (*Neseuretus ramseyensis* HICKS)

Ptychometopus F. SCHMIDT, 1894 (*Calymene volborthi* F. SCHMIDT)

Calymenopsis M. CHALMAS et BERGERON, 1895 (*Calymene filacovi* M. CHALMAS et BERGERON)

Synhomalonotus POMPECKJ, 1898 (*Calymene tristani* BRONGNIART)

Frammia HOLTEDAHL, 1914 (*Frammia dissimilis* HOLTEDAHL)

Liacalymene RAYMOND, 1916 (*Hemicryptus clintoni* VANUXEM)

Colpocoryphe NOVAK, 1918(*Calymene* (*Colpocoryphe*) *inopinata* NOVAK)

Platycoryphe FOERSTE, 1919 (*Calymene platycephala* FOERSTE)

Diacalymene KEGEL 1927 (*Calymene diademata* BARR.)

Metacalymene KEGEL, 1927 (*Calymene baylei* BARR.)

According to REED,[1] *Neseuretus* is a heterogeneous aggregate, in other words, *N. ramseyensis* is apparently identical with *Calymene tristani*, which is the genotype of *Homalonotus*; *N. quadratus* an *Eohomalonotus*; *N. recurvatus*, a *Calymene* resembling *H. heberti* BARROIS; and *N.* ? *elegantus*, an imperfect *Calymene*. Furthermore he added that all those *Neseuretus* came from the Arenig bed, instead of the Tremadoc bed. WARBURG expressed the opinion that neither *Synhomalonotus* nor *Bavariella* are the true ancestors of the family, but probably an earlier offshoot of the evolutional branch.

Colpocoryphe was established in NOVAK's manuscript[2] as a subgenus of *Calymene* (s. l.) in designating the group of *C. argo*. Since BRÖGGER[3] had transferred *Calymene filacovi* from *Calymenopsis* to *Euloma*, *Calymenopsis* may be omitted from the Calymenidae s. str. No description was given of the genotype, *P. verneuili*, so that the genus is a nomen nudum. Moreover, the name *Prionocheilus*[4] has already been taken having been used in 1835 by CHEVROLAT for a beetle.

Frammia[5] has an *Encrinurus*-like cephalon and a *Calymene*-like

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1) F. R. COWPER REED (1918), Notes on the genus *Homalonotus*, (Geol. Mag. New Ser. Dec. VI, Vol. 5,) p. 319.

2) O. NOVAK and J. PERNER (1918), Die Trilobiten der Zone D-$d_{1\gamma}$ von Prag und Umgebung, (Palaeontogr. Bohemiae Nr. IX,) p. 36.

3) W. C. BRÖGGER (1896), Ueber die Verbreitng der *Euloma-Niobe* Fauna in Europa, (Nyt Mag. f. Naturvid. XXXVI,) p. 168.

4) The thanks of the writer are due to Dr. F. R. COWPER REED of the Sedgwick Museum and to Dr. W. E. SCHEVILL of the Museum of Comparative Zoology for their suggestions concerning the genotypes of *Prionocheilus* and *Colpocoryphe* and homonimity of the former.

5) O. HOLTEDAHL (1914), On the Fossil Faunas from Per Schei's series B in South Western Ellesmerland, (Report of the second Norwegian Arctic Expedition in the "Fram" 1898-1902, No. 32,) p. 35.

pygidium, its family reference being questioned by HOLTEDAHL himself.

Distribution of Synhomalonotus:—The *Synhomalonotus* or *Calymene tristani* group, first known from France and Southern England, is widely distributed in Southern and Eastern Asia. The group is represented there by *C. nivalis*, SALTER,[1] *C. birmanica* REED,[2] *C. douvillei* MANSUY,[3] and *Calymene* sp. by KAYSER.[4] *Calymene* (*Synhomalonotus* ?) *pompeckji* here described from Bolivia may be a representative from South America, although it has a prominent anterior precranical projection. Some Asiatic species of *Calymene*, such as, *C. unicornis* REED[5] and *C. tingi* SUN,[6] have also long rostral projections. The tendency of such a projection is to be seen in *S. tristani*.

So far as I am aware, no *Calymene* from the Arcto-American province is referable to *Synhomalonotus*, whence this genus may be a characteristic of the European-Meridional province in the early Ordovician period.[7]

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1) F. R. COWPER REED (1912), Ordovician and Silurian Fossils from the Central Himalaya, (Palaeontol. Indica, Ser. XV, Vol. VIII, No. 2,) p. 101, pl. XIV, figs. 21-22; pl. XV, figs. 1-7.

2) F. R. COWPER REED (1906), The Lower Palaeozoic Fossils of the Northern Shan States, Burma, (Palaeontol. Indica, New Ser. Vol. II, No. 3.)

3) H. MANSUY (1908), Contribution à la Carte géologique de l'Indo-Chine, p. 15, pl. I, figs. 1-12.

4) E. KAYSER (1883) in RICHTHOFEN's China, Vol. IV, p. 38, pl. III, fig 5.

5) F. R. COWPER REED (1917), Ordovician and Silurian Fossils from Yunnan, (Palaeontol. Indica, New Ser. Vol. VI, No. 3,) p. 52, pl. 8, figs. 10-13.

6) Y. C. SUN (1931), Ordovician Trilobites of Central and Southern China, (Palaeontol. Sinica, Ser. B, Vol. VII, Fasc. 1,) p. 29, pl. III, figs. 9a-h.

7) After having finished this manuscript, I read SHIRLEY's interesting paper on the Calymenidae, [J. SHIRLEY (1936), Some British Trilobites of the Family Calymenidae, (Quart. Jour. Geol. Soc. London, Vol. XCII, pp. 384-422, 3 pls.] in which the following scheme of classification is proposed:

Family Calymenidae H. MILNE EDWARDS, 1840

(1) *Synhomalonotus* POMPECKJ, 1898

a) Group without papillate glabellar lobes or buttresses on the fixed cheeks.

(2) *Flexicalymene*, nov. (*Calymene cataractaci* SALTER, 1865)

(3) *Reacalymene* nov. (*Reacalymene limba*, nov.)

(4) *Gravicalymene*, nov. (*Gravicalymeme, convolya*, nov.)

(5) *Metacalymene* KEGEL, 1927, em.

(6) *Platycalymene*, nov. (*Calymene duplicate* (MURCHISON), 1939)

b) Group with papillate glabellar lobes and corresponding buttresses on the fixed cheeks.

(7) *Calymene* s. str. BRONGNIART, 1822

(8) *Diacalymene* KEGEL, 1927, em.

(9) *Papillicalymene*, nov. (*Calymene papillata* LINDSTRÖM, 1885)

Calymene (*Synhomalonotus*?) *pompeckji*, new species.

Plate VI, figures 23-28

1912. *Calymene diademata* Hoek, Op. cit., p. 239, pl. XIII, figs. 4-7.

Description:—Cephalon exclusive of anterior projection, semicircular; glabella truncato-conical; three pairs of deep glabellar furrows oblique, all disconnected on axis; eyes medium-sized, opposed to anterior of glabella; postero-lateral limb of fixed cheek triangular; marginal brim and groove strong; groove crossing brim diagonally from both ends of glabellar front; frontal brim produced forward.

Pygidium subovate; axis conical, consisting of more than six rings; pleura divided into more than six ribs; pleural groove deep; intrapleural groove sometimes seen on external half of pleural rib.

Surface smooth.

Comparison:—The above observations are mostly on internal casts. The preglabellar area is convex and is produced forward into a triangular shape in this species, whereas in *Calymene diademata*, of the Gotlandian, which is the genotype of *Diacalymene* Kegel,[1] the frontal area is distinctly divided into a brim and groove of the same breadth, and it has no projection. A fragment of a thoracic segment and free cheek, which are found associated with the cranidium and pygidium are illustrated.

Calymene boisseli Bergeron[2] and *C. bayani* de Trom. et Lebesc. also have rostral projections. The former species is also similar to this in the pygidium, but the course of facial suture and the glabellar aspect distinguish this species from *Calymenella*.

Formation and locality:—Dark reddish fine sandstone; Cerro Pocotaica.

Family Homalonotidae Pompeckj

Brief Historical Review:—The following names have been proposed for the genera, or subgenera, of the family (invalid names are starred);—

1) W. Kegel (1927), Über obersilurische Trilobitien aus dem Harz und dem rheinischen Schiefergebirge, (Jahrb. Preuss. geol. Landesan. f. 1927, Bd. XLVIII,) p. 618.

2) M. J. Bergeron (1890), Sur. une Forme nouvelle de Trilobite de la Famille des Calymenidae (Genre *Calymenella*), (Bull. Soc. géol. France Ser. 3, XVIII,) p. 365.

Homalonotus König, 1825 [*H. knighti* König]

**Brongniartia* Eaton, 1832, non Leach, 1924 [*Brongniartia carcinodea* Eaton=*Triarthrus becki* Green]

Dipleura Green, 1832 [*D. dekayi* Green]

Trimerus Green, 1832 [*T. delphinocephalus* Green]

**Brongniartia* Salter, 1865 [*H. bisulcatus* Salter]

Burmeisteria Salter, 1865 [*H. herscheli* (Murchison]

**Koenigia* Salter 1865 [*H. knighti* König]

**Plaesiacomia* Corda, 1888 [*Asaphus brevicaudatus* Desl.]

Calymenella Bergeron, 1890 [*Homalonotus* (*Calymenella*) *loisseli* (Bergeron]

Digonus Gürich, 1909 [*H. gigas* Roemer]

**Schizopyge* Clarke, 1913 [*H. longicaudatus* d'Archaic, Fischer et de Verneuil]

Brongniartella Reed, 1918=*Brongniartia* (pars.) Salter [*H. bisulcatus.* Salter]

Burmeisterella Reed, 1918 [*H. elongatus* Salter]

Eohomalonotus Reed, 1918 = *Brongniartia* (pars.) Salter non Leach, nec Eaton [*H. brongniarti* (Desl)]

Parahomalonotus Reed, 1918 [*H. gervillei* de Verneuil]

The name *Brongniartia* by Eaton or Salter has been dropped from trilobite taxonomy, not only because of its preoccupation by Leach, but because of the synonimity of the genotype with Eaton's genus. The generic characteristics of *Plaesiacomia* and *Schizopyge* are not yet precisely known.

Five of the group starred are put aside as invalid, since they have already been pointed out as invalid sections or subgenera of *Homalonotus* by Reed[1] in his revision of the genus. According to him, the remainder are distributed as follows:

Eohomalonotus	Lower Ordovician; N. France Cornwall, Shropshire, Bohemia ?
Calymenella	Ordovician; France.
Brongniartella	Middle and Upper Ordovician; England.
Trimerus	Silurian; Northern Europe, North America, Australia.
Homalonotus s. str.	(*Koenigia*). Silurian; North Europe.
Burmeisteria	Lower Devonian; South Africa, South America (including Falkland Island.)

1) F. R. Cowper Reed (1918). Notes on the Genus *Homalonotus*, (Geol. Mag New Ser. Dec. VI, Vol. 5.)

Digonus	Lower Devonian; Rheinish area, France? England? Argentina.
Burmeisterella	Lower Devonian; Devonshire,? Rheinish area.
Parahomalonotus	Lower Devonian; Europe.
Dipleura	Middle Devonian; North America.

Here two new genera, *Leiostegina* and *Lakaspis*, are established out of the aberrant trilobites, *Leiostegina otaviensis* and *Symphysurus apolinista* respectively, and provisionally referred to this family

Genus BRONGNIARTELLA REED, 1918

Homalonotus (*Brongniartella*?) *bistrami* HOEK

Plate III, figures 15-17

1912. *Homalonotus bistrami* HOEK, Op. cit., p. 249, pl. VIII, figs. 19-20.

The specimen illustrated in fig. 20, pl. VIII, by HOEK, consisting of a cephalon and five or six thoracic segments, is definitely deformed. The cephalon is bordered by a flat brim, well-defined by a narrow groove. The base of the cranidium may be a little wider than one-third of the cephalon. The eyes are located about mid-length of the cranidium. The aspect of the glabella is greatly obscured owing to deformation. The posterior glabellar furrows are apparently strong and oblique. The axis of the thorax is wide.

The pygidium figured by HOEK is better preserved. The axial lobe is wider than, and elevated above, the pleural one and is divided into about twelve rings. However, the last three or four cannot exactly be counted. The segmentation is quite obsolete on the pleural lobe; the marginal border and groove are rather well-defined.

Still another specimen of the cranidium procured from Palca del Tunari, near Cochabamba, probably belongs to this species. This being also deformed secondarily, the original outline cannot be made out. The glabella, at least in its posterior half, is parallel-sided and is marked off by a pair of deep grooves; the eyes are relatively large and located about the middle or slightly posterior; the occipital furrow is distinct. The posterior branch of the facial suture may be diagonal.

Little can be said of such a deformed cranidium, but it may be closer to *Homalonotus* (s. l.) than anything else. The associated

1) J. W. SALTER (1865), A Monograph of British Trilobites (Palaeontogr. Soc.) p. 105, Pl. X, figs. 2-10.

pygidium is rather similar to *Homalonotus bisulcatus*,[1] although the pleural lobe of the pygidium is smooth in this species.

Formation and locality:—The pygidium was collected from Isaipate near Cochabamba; the deformed carapace and cranidium from Palca Tunari, near Cochabamba, in association with *Leiostegina otaviensis*. Further, HOEK cites that *H. bistrami* occurs at Totorapampa.

Genus LEIOSTEGINA KOBAYASHI, 1937

1937. *Leiostegina* KOBAYASHI, Proc. Imp. Acad. Vol. 13, p. 14.

Genotype:—*Leiostegina inexpectans* KOBAYASHI

Remark:—The general aspect of the cranidium is quite suggestive of an affinity with the Leiostegidae, especially with the Illaenurinae, but the absence of the frontal brim is quite distinct, and also the outline of the glabella, its small middle eyes, and parallel anterior facial sutures distinguish this genus from the three genera of that subfamily. The associated pygidium is absolutely distinct from that of the Leiostegidae, for which reason I am rather inclined to believe that the genus may be related more to the Homalonotidae than to the Leiostegidae. In the former family the glabellar area varies in size. *Homalonotus bisulcatus*, which is the genotype of *Brongniartella*, has a very narrow preglabellar area. If the area is reduced further, the aquired cranidium will be quite allied to this one, and the associated pygidium will be rather typical of the Homalonotidae.

Leiostegina inexpectans KOBAYASHI

Plate VI, figures 18-20

1937. *Leiostegina inexpectans* KOBAYASHI, Proc. Imp. Acad. Vol. 13, p. 14.

Description:—Cranidium subtrapezoidal; glabella long, truncato-conical, slightly contracted at point one-third from front, slightly elevated above cheek; no glabellar furrows except for the occipital one; occipital ring narrow; eyes small, at mid-length of cranidium fixed cheek narrow and of equal breadth anterior to eye and that posterior to eye, triangular; no frontal brim; facial sutures parallel in front of eyes and diagonal behind them.

Pygidium convex, relatively small; its posterior part bent up at middle; axis convex, marked off by deep groove and divided into

more than eight rings, but the posterior ones obsolete; marginal brim narrow ill-defined.

Formation and locality:—Greenish sandstone; west of Otavi, Bolivia.

Genus LAKASPIS Kobayashi, 1937

1937. *Lakaspis* Kobayashi, Proc. Imp. Acad. Vol. 13, p. 14.

Generic diagnosis:—Cephalon semi-circular, bordered by strong brim; glabellar outline distinctly contracted near front where eyes are opposed; occipital ring distinct. Pygidium subtriangular in outline; articulating segment and conical axial lobe well marked by furrows.

Genotype:—*Symphysurus apolinista* Lake

Lakaspis apolinista (Lake)

Plate II, figure 27, 28

1906. *Symphysurus apolinista* Lake, Trilobites from Bolivia, (Q.J.G.S. London, Vol. 62,) p. 427, pl. XL, figs. 2-3.

A description has already been given by Lake. The measurements are made from the holotype as follows:—

Length of cephalon	4.5 mm.
Breadth of cephalon	6 mm.
Length of glabella	4.4 mm.
Breadth of glabella	2.9 mm.
Distance between the eyes	about 3 mm.
Distance between the eye and posterior margin of cephalon	2.8 mm.
Length of pygidium.	about 3.6 mm.
Breadth of pygidium	about 4.5 mm.
Length of axial lobe	3.4 mm.
Breadth of axial lobe	2.1 mm.

As mentioned by Lake, "this form is not unlike *Symphysurus incipiens* Brögger, but the greatest constriction of the glabella is not any more forward than in that species, the eyes are smaller, and the tail apparently not marginate." Not only these, but the absolute distinctions from *Symphysurus*, are the occipital lobe outlined in the whole length, absence of median tubercle from the glabella on the cephalon, while on the pygidium the distinct articulating segment and conical axial lobe are marked by a furrow in the whole periphery.

In taking these general appearances into account I was first

impressed with its marked resemblance to the Shumardidae. It, however, differs from the family in the character of facial suture. The outline of the glabella. anterior eyes, and strong marginal brim of cephalon are also distinct from *Shumardia* BILLINGS, *Idiomesus* RAYMOND, and *Koldinioidia* KOBAYASHI.

Another affinity to it that I now think of is in the Homalonotidae, especially *Leiostegina*. But a difference, which can hardly be overlooked, is the isopygous nature of this genus. This is certainly a new genus, but its reference to the Homalonotidae is only tentative.

Formation and locality:—Large blocks of sandstone (not *in situ*) about a mile from Apolo, Province of Caupolican, in a direction slightly west of north.

Family Trinucleidae EMMRICH

Three species of trinuclids have been described from South America as follows:—

1) *Trinucleus boliviensis* LAKE
2) *Trinucleus krugeri* HOEK
3) *Trinucleus nordenskiöldi* BULMAN

Genus TRINUCLEUS MURCHISON, 1839

Trinucleus boliviensis LAKE

Plate III, figure 1

1906. *Trinucleus boliviensis* LAKE, Q. J. G. S. London, Vol. LXII, p. 427, pl. XL, figs. 4-5.

1927. *Trinucleus boliviensis* STETSON, the Distribution and Relationships of the Trinucleidae, (Bull. Mus. Comp. Zool. at Harvard Coll. Vol. LXVIII, No. 2,) p. 99.

Glabella pyriform and elevated; three pairs of short glabellar furrows extending for a short distance on both sides of the axial furrow; the fringe divided into a row of rectangular pits; the radial ridge between the pits extends for a short distance beyond the margin of the fringe into the cheek; no eye; genal spine short.

Surface texture, and structure within the pit are uncertain. This is allied to *Trinucleus* in many respects, but the aspect of the glabellar furrows and the fringe in addition to the presence of genal spine, do not fit in with any species of the genus. If better specimens are found, this might be segregated, even from *Trinucleus* s.

str. as a new genus,

Formation and locality:—A light coloured friable sandstone block; about a mile from Apolo, Province Caupolican, in a direction slightly west of north.

Trinucleus krugeri Hoek

Plate, V figure 13-14

1912. *Trinucleus krugeri* Hoek, Op. cit., p. 236, pl. X, figs. 7-8.
1927. *Cryptolithus krugeri* Stetson, Bull. Mus. Comp. Zool. Havard Coll. Vol. LXVII, No. 2, p. 99.
1936. *Trinucleus krugeri* Störmer, Scandinavian with Special References to Norwegian Species and Varieties, (Skrift. Utg. av. Det. Norsk Videns.-Akad. i. Oslo, I, Mat-Naturv. Kl. No. 4,) p. 15.

This species is described in detail by Hoek and compared with *Trinucleus ornatus* Sternb. and *T. bureani* Oehlert, both being referred to *Crytolithus* by Stetson. In France *C. ornatus* is associated with *Synhomalonotus tristani*. Hoek's species is referred to *Cryptolithus* by Stetson and to *Trinucleus* of the *foveolatus-bronni* group by Störmer. From the distinct radial sulci of the fringe I am inclined to follow Störmer's opinion. The aspect of the pygidium however, reveals quite distinct specific character.

The glabella is narrower than the cheeks; three sets of glabellar pits are distinct; cheek arched, with indistinct trace of eye-tubercle(?) at its center; glabella and cheek pitted; fringe narrows toward genal angle, slightly convex and sloping toward brim; sulcus deep. The pygidium is transversely triangular; axis half as broad as pleura; more than eight rings counted on axis; pleural lobe divided into large anterior facet and about six pleural ribs.

Formation and locality:—Dark reddish fine sandstone; Cerro Pocotaica near Capinota in the tributary of the Rio Arque.

Suborder DIKELOCEPHALIDA Kobayashi

Family Asaphidae Burmeister

Genus NIOBELLA Reed, 1931

Niobella (?) sp.

1906. *Ogygia* sp. (partim) Lake, Trilobites from Bolivia, (Q. J, G. S. London, Vol. LXII,) p. 428, fig. 7.

I wonder if this hypostoma and the pygidium (fig. 6 in LAKE) do not belong to an identical species, seeing that the former is in a black shale, while the latter is in a hard sandstone in association with another hypostoma.

So far as I can see, this hypostoma (fig. 7 in LAKE) has an entire posterior margin, inside of which there runs a groove; its anterior margin moreover develops into wings at its extremities. As compared by LAKE, this hypostoma seems to be allied to that of *Ogyginus*, such as *O. selwynii* (SALTER,), which in turn may be associated with *N. homfrayi* referred to *Niobe* in REED's recent revision.[1]

Formation and locality:—Black shale; right bank of the River Cara, between the mouth of the River Challana and that of the Coroico, Province of Caupolican, Bolivia.

Genus OGYGINUS RAYMOND, 1912

Ogyginus (?) sp.

Plate III, figure 7; Plate V, figure 9

1906. *Ogygia* sp. LAKE, Trilobites from Bolivia, (Q. J. G. S. London, Vol. LXII,) p. 428, fig. 6.

As discussed already, this should be separated from the preceding as a distinct species. In the collection in the British Museum, there are a free cheek and hypostoma besides pygidia. The free cheek has a well-marked border; the facial suture niobi-form; and eyes located at about mid-length of the cephalon. The hypostoma has small lateral wings, and a posterior pit is provided on each side. The pygidium has a fairly prominent axis and a concave border, which in turn narrow forward. About ten rings may be counted on the axis; seven segments are observable on the pleural lobe.

The hypostoma closely resembles that of *Megalaspis*, such as of *M. planilimbata* and *M.* cfr. *acuticauda*, but the niobi-form facial suture precludes this generic reference, and its proper position may be found in *Ogyginus* or its ally.

Formation and locality:—Same locality as the preceding, but in hard sandstone, instead of black shale.

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1) F. R. COWPER REED (1931), A Review of the British Species of the Asaphidae, (Ann. Mag. Nat. Hist. Ser. 10, Vol. VII,) p. 463.

Genus HOEKASPIS, new genus

Generic diagnosis:—Asaphid with long glabella expanded in front and bordered by deep dorsal furrow; eyes mid-length of cephalon; free cheek with genal spine; pygidium with segmented axis and well-marked brim and groove.

Genotype:—*Megalaspis matacensis* HOEK

Remark:—Distinctions from the resembling genera are given in the description of the genotype.

Hoekaspis matacensis (HOEK)

Plate III, figure 18; Plate VI, figures 15-17

1912. *Megalaspis matacensis* HOEK, Op. cit., p. 233, pl. XII, fig. 6-7.

A detailed description has already been given by HOEK, but he unfortunately omitted to compare it with allied forms.

Glabella long, reaching frontal end, parallel-sided, but more or less expanded and drooping in front; both its sides well marked by deep and wide dorsal furrows; glabellar furrows distinct: strong elevation seen at median point of third axial lobe; occipital lobe narrow, slightly thickened in middle; eyes relatively large, close together, slightly anterior to mid-length of glabella; fixed cheek narrow. Free cheek consists of swollen inner part and convex marginal brim, which in turn, is thickened backward and produced into genal spine; marginal groove wide but shallow; facial suture diagonal behind eye and cuts articulating margin at about middle point of cheek, and in front of eye, runs slightly outwardly, but incurved abruptly at junction with marginal border. Pygidium gently convex; axis elevated above pleural lobes and divided into more than eight rings; segmentation greatly obsoleted on pleural lobe; the marginal border strong.

Comparison:—These observations on the cephalon make no reference to *Megalaspis*, but leads this species into the neighbourhood of *Niobe* and *Niobella*. None of the two last-named genera, however, have not the genal spine on the cheek and a strong brim on the pygidium as in this species. Furthermore, the glabella is long, the glabellar furrows are strongly impressed, and the facial suture runs within the marginal border to some length.

This differs from *Hemigyraspis* by its long glabella and distinct marginal grooves of the cephalon and pygidium; from *Bellefontia* by its deep parallel dorsal furrows and drooping glabellar front; from *Homalopteon* by the position of the eye and especially by the pygidium which, in *Homalopteon* is similar to those of some dikelocephalids, as suggested by REED.[1] The general aspect of the glabella is more or less similar to *Symphysurus* and *Nileus*, but the pygidium is entirely distinct.

Formation and locality:—Red quartzite; west of Mataca, Pampa of Otavi, and Cerro Pocotaica, Bolivia.

Hoekaspis mesops, new species

Plate III, figure 11; plate VI, figures 12-14

The preceding form is contained in a red quartzite, while this is in a chocolate-coloured shale, so that it may be surmised that the differences are due to preservation, but careful examination shows that the two should be distinguished specifically.

Compared with the preceding, this has a more expanded anterior of the glabella, obsolete glabellar furrows, large elevated compound eye, and small postero-lateral limb of the fixed cheek; on the pygidium, the articulating facet and marginal groove are quite distinct.

A fragment of a thoracic segment indicates that the pleural end is sharply pointed.

Formation and locality:—Chocolate-coloured shale of La Glorietta, Sucre.

Genus ASAPHELLUS CALLAWAY, 1877

Subgenus ASAPHELLOIDES, KOBAYASHI, 1937

1937. *Asaphelloides* KOBAYASHI, Proc. Imp. Acad. Vol 13, p, 14.

Generic diagnosis:— *Asaphellus* with a slightly forked hypostoma.

Genotype:—*Megalaspis* (?) *americana* HOEK.

Asaphellus (*Asaphelloides*) *americana* (HOEK)

Plate V, figures 1-6

1) F. R. COWPER REED (1931), Ann. Mag. Nat. Hist. Ser. 10, Vol. VII, p. 469.

1912. *Megalaspis* (?) *americana* HOEK, Op. cit., p. 220, pl. 10, fig. 5, (figs. 4 & 6 ? not figs. 2 & 3.)

1935. *Asaphellus* (?) *catamarcensis* KOBAYASHI, Japan. Jour. Geol. Geogr. Vol. XII, p. 65, pl. XI, figs. 11-15.

1937. *Asaphellus* (*Asaphelloides*) *americana* KOBAYASHI, Proc. Imp. Acad. Vol 13.

Description:—Cephalon semi-circular with short genal spine, gently convex and sloping gradually toward flat, or even slightly concave marginal border; glabella ill-defined by weak parallel axial grooves; median pustule located at median point between posterior ends of eyes; no glabellar furrow; occipital furrow traceable only on cheek; palpebral lobe of median size, opposite and close to middle of glabella; facial suture isoteliform. Hypostoma long; central body well marked off from border by groove, and provided with pair of maculae and pair of depressions inside maculae; posterior wings, tiny, shallow sinuation between; anterior margin of hypostoma bent back embracing on both sides and produced into pair of short wings.

Thorax parallel-sided; axial ring ill-defined and as wide as pleura; pleura somewhat truncated at lateral end; pleural ridge oblique, crossing middle one-third of pleura.

Pygidium semi-ovate surrounded by concave border; axial lobe teretely conical, sometimes distinctly elevated behind; segmentation obsolete; about eight rings on axis; on pleural lobe only anterior three or four segments marked by furrows.

Surface smooth.

Comparisons:—*Asaphellus* (?) *catamarcensis* is most probably identical with this species, the two points of difference are that the free cheek of that species (fig. 12, pl. XI, 1935) has no distinct concave border and that the hypostoma has an entire posterior. But I have seen another free cheek from the same locality which has a well-defined flat border, the hypostoma being practically identical with each other in other respects. I am not certain, that the posterior spines were not lost in the hypostoma from Prairie Catamarca.

In a dorsal view of the carapace, this species is diagnostic for *Asaphellus*, but the associated hypostoma is quite distinct. As no other asaphid has been found in this shale, quite possibly this hypostoma is combined with other parts in one species. As to the hypostoma of *Asaphellus homfrayi*, a question was raised by REED. Compared with CALLAWAY's hypostoma from the Shineton shale

which, according to REED,[1] might not be one of *A. homfrayi*, the former is much wider than the present hypostoma. The hypostoma from Garth, which SALTER originally referred to *A. homfrayi*, has similar outline to this species. An essential distinction from both SALTER's and CALLAWAY's, however, is to be recognized in the posterior sinuation, in which respect this hypostoma recalls some resemblance to those of *Megalaspis limbata*, *Ptychopyge acuta*, and some species of *Niobe*. The dorsal view of the carapace, however, precludes reference of this species to either one of these genera. After all, this combination of characteristics segregates this as a distinct trilobite, for which I propose a new subgeneric name, *Asaphelloids*.

Formation and locality:—*Kainella* bearing dark coloured shale; Cuesta de Erquis.

Genus MEGARASPIDELLA KOBAYASHI, 1937

1937. *Megalaspidella* KOBAYASHI, Proc. Imp. Acad. Vol. 13, p. 15.

Generic diagnosis:—Megalaspids with a smooth conical glabella, large middle eye, concave border, genal spine, and isoteliform facial suture on the cephalon; pygidium subtrapezoidal, surrounded by a concave border and its axis multisegmented.

Genotype:—*Megalaspidella kayseri*, new species.

Remarks:—The urceolate glabella is characteristic of the Asaphidae. However in the Lower Ordovician asaphids, one sometimes meets with subcylindrical glabella. *Megalaspis*, *Paramegalaspis*, and *Hemigyraspis* are examples. Except some species of *Niobe* in the Lower Ordovician and *Eoasaphus*[2] in the Upper Cambrian, none have conical glabella. The last two genera, however, have the niobiform, instead of the isoteliform as in *Megalaspidella* facial sutures.

Megalaspidella kayseri KOBAYASHI

Plate V, figures 7-8

1897. *Megalaspis* sp. KAYSER, Zeits. deuts. geol. Gesell. Bd. XLIX p. 281. pl. VII, figs. 10-11, text-fig.

1937. *Megalaspidella kayseri* KOBAYASHI, Proc. Imp. Acad. Vol. 13, p. 15.

1) F. R. COWPER REED (1931), Ann. Mag. Nat. Hist. Ser. 10, Vol. VII, p. 456.

2) A. H. WESTERGÅRD (1922), Sveriges Olenidskiffer, (Sveriges Geol. Undersökn. Ser. Ca, Nio 18,) p. 194, pl. II, fig. 20.

T. KOBAYASHI (1936,) Three Contributions to the Cambro-Ordovician Faunas, (Japan. Jour. Geol. Geogr. XIII,) p. 178.

Not only the pygidia illustrated by KAYSER but also a cradidium and free cheek are in the Mudana collection.

Description:—Cephalon exclusive of genal spines semi-circular, gently convex, surrounded by concave border; glabella conical, rounded in front, slightly convex and slightly elevated above cheeks; dorsal furrow distinct in posterior half; no glabellar furrows; articulating occipital ring narrow, depressed, well defined; palpebral lobe relatively large, elevated, located at mid-length of cranidium and close to glabella; occipital lobe has an ordinal breadth on fixed cheek; genal spine short; facial suture anterior to eye, isoteliform; that posterior to eye more or less transversal, then abruptly bent back, in taking a vertical course, cutting median point of basal margin of cheek.

The pygidium has already been described by KAYSER. Its characteristics are a truncated posterior outline, distinct brim, well marked articulating facet and outline of axis, which is conical in the anterior half and cylindrical in the posterior. The segmentation is usually distinct on the axial lobe, but considerably obscured on the pleural.

Comparison:—The outline of the pygidium readily distinguishes this species from *Megalaspis planilimbata*. The outstanding features of this trilobite are the outline of the glabella and relatively anterior large eye. This cranidium is similar to that of KAYSER's *Megalaspis* sp. from Salta, (KAYSER, 1898, Pl. XVI, fig. I). The two, however, can be distinguished by the outline of the glabella, which is really subsquare in the Salta form.

Furthermore, the glabella seems to be elevated considerably above the cheek. None of the pygidia found associated with this cranidium from Salta have such subtrapezoidal outlines, but are, instead, triangular, and the posterior end is sometimes produced into a spine.

Formation and locality:—Lower Ordovician sandstone; Mudana, south of Humahuaca, Jujuy, Argentina.

Genus XENOSTEGIUM WALCOTT, 1924

Xenostegium brackebuschi (KAYSER)

Plate III, figure 21

1898. *Megalaspis brackebuschi* KAYSER, Op. cit., p. 428, pl. XVI, fig. 3.

Pygidium gently convex and subtriangular; axial lobe nearly

flat and slightly elevated above pleural lobes which, in turn, gently slope down toward margin; marginal brim slightly concave, while pleural lobe gently convex; segmentation indistinct but discernible; tiny spine produced at posterior end of pygidium.

KAYSER compared this species with *Megalaspis heros.*[1] It appears to me that better agreement is found with *Xenostegium* (?) *laticaudum*,[2] although this is still distinct. *X.* (?) *laticaudum* has a more prominent axial lobe and well-marked marginal brim than *X. brackebuschi*.

Formation and locality:—Lower Ordovician; Salta, Argentina.

Xenostegium saltensis (KAYSER)

Plate III, figure 2

1898. *Pterygometopus saltensis* KAYSER, Op. cit., p. 428, pl. XVI, fig. 4.

Subtriangular pygidium, narrow axis, gently convex and narrow pleural lobe and the well-defined brim suggest affinity with *Xenostegium euclidus*,[3] but the pleural lobes are well-segmented and the posterior spine cannot be clearly seen in this species.

Formation and locality:—Lower Ordovician; Salta, Argentina.

Genus THYSANOPYGE KAYSER, 1898

Thysanopyge argentina KAYSER

Plate III, figures 19-20

1898. *Thysanopyge argentina* KAYSER, Op. cit., p. 425, pl. VI, fig. 2.
1898. *Megalaspis* sp. KAYSER, Op. cit., p. 427, pl. VI. fig. 1.

Thysanopyge has escaped the attention of paleontologists for a long time, but as noticed elsewhere,[4] this is an interesting endemic genus of asaphid in South America. The genus is based on a single cast of pygidium, which is well-characterised by an indented margin and a long caudal spine. This is certainly similar to some species of *Megalaspis* and *Xenostegium*, but both genera have no indentation along the margin. The axis reduces its prominence on the posterior

1) W. C. BRÖGGER (1882), Die silurischen Etagen 2 u. 3 in Kristianiagebiet und auf Eker, p. 85, pl. IV, figs. 3-4.

2) KOBAYASHI (1834), Jour. Fac. Sci. Imp. Univ. Tokyo. Sect. II, Vol III, Pt. 9, p. 559, pl. V, figs. 1, 6-7.

3) WALCOTT (1925), Op. cit., p. 126, pl. 24, figs. 13-14.

4) T. KOBAYASHI (1936). Cambrian and Lower Ordovician Trilobites from Northwestern Canada, (Jour. Paleont. Vol. 10,) p. 163.

brim, as seen in *Xenostegium albertensis*,[1] but the segmentation is quite distinct, and the pleural rib has an intrapleural furrow near the margin which distinguishes this species from *X. albertensis*.

A cranidium is found in the same collection and referred to *Megalaspis* by KAYSER. This is incorrectly illustrated in fig. 1, pl. VI. As shown in fig. 19, pl. III, this paper, the glabella is subsquare, instead of subconical in outline and more or less contracted in the middle where the eyes are opposed, but not preserved in the specimen. The three short, oblique glabellar furrows illustrated by KAYSER are in fact indiscernible. The preglabellar area is rather wide and somewhat concave.

Of the three pygidia described from the same place, two belong to *Xenostegium* (s. l.), the cranidium of which is quite distinct from any of *Xenostegium*. Therefore there is a chance that it is in *Thysanopyge*, although the combination of detached cranidium with a pygidium is no more than a good guess. If the two can be combined, the genus, *Thysanopyge*, is quite well characterised.

Formation and locality:—Lower Ordovician quartzose sandstone · Salta, Argentina.

Genus BASILICUS SALTER, 1849

Basilicus aff. *tyrannus* (MURCHISON)

Plate VI, figure 21

1912. *Asaphus* cf. *tyrannus* HOEK, Op. cit., p. 235, pl. X, fig. 1.

STEINMANN'S collection contains four pygidia of *Basilicus*. The best one as illustrated by HOEK has wide triangular outline, not truncated behind; pleural rib rounded, bent back rather conspicuously at their extremities and separated from one another by groove of equal breadth; marginal border horizontal and its inner margin rather sharply defined by change in inclination.

In the Korean species of *Basilicus* the pygidium is more multisegmentated than this, in which respect this is allied to *B. tyrannus*. It, however, still remains distinct from the British species by its wide pygidium, no truncation of the posterior margin, and smooth axial lobe. Until more can be known of the carapace, I hesitate to give a new name to this species.

1) C. D. WALCOTT (1925), Smiths. Misc. Coll., Vol. 75, No. 2, p. 125, pl. 24, fig. 10-11.

The other three are enrolled laterally, so that thier specific identity with the preceding is not warranted, but they certainly belong to *Basilicus*. One of them shows a trace of the doublure, which occupies the whole breadth of the flat margin.

Formation and locality:—The specimen illustrated by HOEK was procured from a greenish yellow calcareous sandstone with argillaceous layers in the region of springs in Pilcomayo, Escaleras Pass, between Mataca and Tambillos. HOEK mentions that *Gomphoceras* (?) sp. is associated with it. Another one almost identifiable with this species was collected from a sandstone of the upper Pilcomayo area, south of Escaleras. Two considerably rolled pygidia came from the sandstones of Taquina and San Juan near Tarija. Since the generic range of *Basilicus* is confined, so far, to Middle Ordovician, the age of this *Basilicus* sandstone may be inferred.

Genus PARABASILICUS KOBAYASHI, 1934

Parabasilicus aff. *typicalis* KOBAYASHI

Plate V, figures 11-12

1912. *Asaphus powisii* HOEK, Op. cit., p. 236.

The specimen HOEK described is a large and broad pygidium belonging to the *Asaphus powisii* group, for which in turn, *Parabasilicus*[1] was instituted with *Parabasilicus typicalis* for its genotype. *Asaphus powisii* was suggested as being referable to this genus, the suggestion being subsequently accepted by COWPER REED.[2]

Two smaller pygidia (b, c) are found in the same slab and a medium-sized one (d) in another slab. They vary in the ratio between their length and breadth, but are not essentially different. I belive that the first slab containing the specimens (a, b, c) may be deformed to some extent and that specimen (d) will show the original outline.

This form is certainly close to *P. powisii*,[3] but its axis tapers

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1) T. KOBAYASHI (1934), The Cambro-Ordovician Formations and Faunas of South Chosen, Palaeontology, Pt. I, Middle Ordovician Faunas, (Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. II, Vol. III, Pt. 8,) p. 477.

2) F. R. COWPER REED (1935), The Palaeozoic Trilobites of Girvan, Suppl. No. 3, (Palaeont. Soc.) p. 13.

3) J. W. SALTER (1866), A Monograph of British Trilobites, Pt. III, (Paleontgr. Soc.) p. 134, p. XXIII, figs. 27.

regularly and slowly backwards, whereas in *P. powisii* it is wide in the front and narrows rather abruptly in the short distance from the anterior end, making the side of the axis concave. It is allied also to *Parabasilicus larviculus*,[1] but RAYMOND's species has an arched articulating margin, conical axis, and obsolete segmentation.

After all, the nearest species will be found in the oriental species of *Parabasilicus*, the distinction among which is based on the relative length of the cephalon, thorax, and pygidium; the presence or absence of genal spines, and so forth. With only a detached pygidium, I could hardly make any specific identification.

Formation and locality:—Specimens a–c were procured in the upper courses of the Pilcomayo, Bolivia. Specimen d is found at a point south of the Escaleras pass with *Basilicus* aff. *tyrannus*. Since the *Parabasilicus* is a characteristic genus in the Middle Ordovician, this, together with *Basilicus*, makes a noticeable display of Middle Ordovician sandstone in the Pilcomayo area.

Genus PSEUDOBASILICUS REED, 1931

Pseudobasilicus (?) *liquesis* (HOEK)

Plate V, figure 10

1912. *Ogygia liquensis* HOEK, Op. cit., p. 230, pl. XIV.

This is a large asaphid, the anterior of the cephalon and the pygidium of which are not preserved.

Carapace flat; glabella in same niveau with cheeks, parallel-sided behind eyes and broadly expand anterior to them; no glabellar furrow; dorsal furrow shallow, but wide; eyes relatively small, close to mid-length of glabella and elevated; occipital furrow distinct on cheek; marginal brim and groove of same breadth, the latter of which is entrenched below neveau of cephalon; genal spine present; facial suture posterior to eye diagonal in concavo-convex curvature and cutting articulating margin at median point of cheek; that anterior to eye diagonal, but abruptly incurved at its junction with marginal groove.

Axial lobe of thorax narrower than pleural and slightly elevated;

1) P. E. RAYMOND (1925), Some Trilobites of the Lower Middle Ordovician of Eastern North America, (Bull. Mus. Comp. Zool. at Harvard Coll. Vol. XLVII, No. 1,) p. 85, figs. 15-16, pl. 6, fig. 15.

pleura rather transverse, pointed at extremity; pleural ridge crossing pleura from point slightly inside of middle of pleura to lateral end; deep groove running parallel to ridge.

The specimen is in a concretion of compact slate. The convexity of the carapace might be reduced secondarily. Since the front of the cephalon is not preserved, whether the facial suture is niobiform or isoteliform is uncertain. The most conspicuous characteristic is the outline of the glabella.

HOEK compared this to *Ogygia marginata* CROSSFIELD and SKEAT, *Ogygia selwynii* SALTER and *Ogygia desiderata* BARR. The first species was referred to *Ogyginus* and the second to *Niobella* by REED,[1] while the third was referred to *Hemigyraspis* by RAYMOND.[2] The distinctions among these species have already been pointed out by HOEK. Through the presence of the genal spine it is easily distinguished from *Niobe* and *Niobella*.

Since little is known of its hypostoma and facial suture, it is difficult to discuss its generic determination with any accuracy, but the facial suture appears to be intramarginal, at least at some length, so that I suggest that this might be an *Ogyginus* or *Ogygites* of RAYMOND.[3] REED[4] established a new genus *Pseudobasilicus* for RAYMOND'S *Ogygites*, because *Ogygites* TROMELIN and LEBESCONTE[5] have an entire hypostoma, while RAYMOND'S has a forked one. Although the final decision, however, depends upon the hypostoma and facial suture, it might be said that the pleural end of the thorax is usually truncated in *Ogygites*, although pointed in *Pseudolasilicus*. From this thoracic character it is more likely to be a *Pseudobasilicus*.

Formation and locality:—Boulder found at Sivingomayo, Cordillera de Lique, Bolivia.

Family Uncertain

Trilobite (*Angelina* ?) gen. et. sp. indt.

Plate IV, figures 21-22

A free cheek and a fragment of the cranidium are at hand.

1) F. R. COWPER REED (1931), Ann. Mag. Nat. Hist. Ser. 10. Vol, VII, pp. 461-464.

2) P. E. RAYMOND (1910), Note on Ordovician Trilobites II, (Ann. Carnegie Mus. Vol. VII, No. 1,) p. 38.

3) P. E. RAYMOND (1912), Notes on Parallelism among the Asaphidae, (Trans. Royal Soc. Canada, Third. Ser. Vol. V, Sect. IV,) p. 115.

4) F. R. COWPER REED (1931) Op. cit., pp. 451-452.

5) R. & E. RICHTER (1924), Unterlagen zum Fossilium Cata'ogus, Trilobita, I, (Senckenbergiana Bd. VI, Hft. 516,) pp. 213, 233.

The eye is medium-sized and located about mid-length of the cranidium; glabella rounded in front; frontal brim narrow, straight and punctated along its inner margin. The free cheek has a distinct brim and a long genal spine.

These observations apparently suggest some affinity with *Angelina*, but is probably distinct, because the facial sutures are rather distinctly divergent anterior to the eyes and the frontal brim is not triangular as in *Angelina*. With such imperfect specimens, exact determination is scarcely possible.

Formation and Locality:—Late Upper Cambrian green sandstone; Guanacuno, Bolivia.

Hypostoma a, gen. et sp. indt.

Plate III, figure 6

Hypostoma elongately subovate; central body convex, produced backward and united with backwardly arched ridge; marginal border narrow, flat, and depressed; extremities of anterior margin rectangular.

This hypostoma is found associated with a group of cranidia of *Plethopeltis microphthalmus*.

The hypostoma is 9 mm. long and 5.5 mm. broad, while the largest cranidium in the same slab is 8.5 mm. long. On a cranidium of *P. microphthalmus* from the same locality in another slab, however, the length of the cranidium measures 14 mm. Therefore, the hypostoma might belong to *Plethometopus microphthalmus*.

Formation and locality:—Sandstone of Patacas Tacsara, Bolivia.

Hypostoma b, gen. et sp. indt.

Plate II, figure 25

Hypostoma subsquare; posterior margin broadly rounded and anterior one straight and somewhat auriculatod at extremities; central body relatively large-sized, surrounded by deep groove and elevated narrow brim; posterior stout ridge running along central body.

Its general aspect is suggestive of the Dikelocephalidae rather than the entire hypostoma of the Asaphidae. The hypostoma of *Dikelocephalus* from the Upper Cambrian of the Upper Mississippi

valley, however, is wider and has relatively small central bodies and maculae, and subangulate posterior outline. The hypostomata of *Saukia pepinensis* (OWEN) and *Dikelocephalus insolitus* RAYMOND are quite similar. The hypostomata are associated with distinct Lower Ordovician trilobites and no Dikelocephalidae is contained in it. All of which makes it difficult for me to determine its taxonomic positions.

Formation and locality:—*Kainella* shale of Cuesta de Erquis, Tarija, Bolivia.

Order NOTOSTRACA SARS

Family Eopteridae MILLER

Genus TECHNOPHORUS MILLER, 1889

Technophorus otaviensis KOBAYASHI

Plate VII, figure 8

1936. *Technophorus otaviensis* KOBAYASHI, Jour. Geol. Soc. Japan, Vol. 43, p. 352, text-figs. 6-7.

Carapace semi-circular in anterior half and subtriangular in posterior; umbo located about one-third from anterior end; obtuse plication running along postero-dorsal margin short distance from it; basal margin gently sinuated in front of plication; surface marked by concentric ribs.

An internal cast in a figure, plate VII, shows the internal clavicle which is nearly vertical.

This is quite distinct from the multiplicate forms or those with a median groove on the plication, such as *Technophorus sulcatus* ULRICH[1], *T. plicata* (BILLINGS)[2] and *T. punctostitatus* ULRICH var. *quincucialis* FOERSTE.[3] The plication is not so sharply elevated as in *T. divaricatus* ULRICH and *T. filistriatus* ULRICH,[4] nor is it provided

1) E. O. ULRICH (1897), The Lower Silurian Lamellibranchiata of Minnesota, (Geol. Minn. Vol. III, Pt. II,) p. 614, pl. XI, figs. 30-34.

2) W. T. TWENHOFEL (1928), Geology of Anticosti Island, (Mem. Geol. Surv. Ottawa, 154), p. 340, pl. XVI, fig. 8.

3) A. F. FOERSTE (2924), Notes on the Lorraine Faunas of New York and the Province of Quebec, (Bull. Sci. Lab. Denison Univ. Vol. XVIII,) p. 316, pl. II, figs. 13a-b.

4) ULRICH (1897), Op. cit., p. 615, pl. XL, figs. 35-36; p. 611, pl. XI, figs. 37-38.

with a groove on each side as in *T. faberi* MILLER.[1] The concentric ribs vary in their strength with individuals, but none are cancellated as *T. cancellatus* RUEDEMANN.[2] *T. extenuatus* ULRICH[3] is distinct from this by the acute bend of the posterior outline. These distinctions indicate that this species is new.

Formation and locality:—Sandstone; Otavi, Bolivia.

INCERTA SEDIS

Genus CRUZIANA D'ORBIGNY, 1842

Since D'ORBIGNY[4] created this genus with *Cruziana rugosa* and *C. furcifera* from the Ordovician of South America, two Ordovician species, *cucuribita* and *unduwi*, were added by SALTER[5] and a Devonian species, *andina*, by ULRICH.[6] Both STEINMANN and HOEK state that *Cruziana* is widely distributed in Northeastern Bolivia, which marks the *Bilobites* sandstone in the Ordovician strata.

In Europe this problematicum is known to be distributed widely in the Ordovician and less so in the Cambrian, *Cruziana dispar* (LINNARSSON) and *C.* (?) *orbicularis* TORELL[7] are the Lower Cambrian members of Sweden and *C. sardoa* (MENEGHINI)[8] that of Sardinia, in which island *Cruziana* occurs also in the Ordovician formation.

SAMPELAYO[9] described two new species, *meryi* and *schulzi*, besides *planus*, from the Cambrian of Spain, and SAMSONOVICZ[10] announced the occurrence of the genus in the Upper Cambrian of Poland.

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1) S. A. MILLER (1886), North American Geology and Palaeontology, p. 514, fig. 930.

2) R. RUEDEMANN (1901), Hudson River Beds near Albany, etc., (Bull. N. Y. State Mus. Vol. 42,) p. 572, pl. I, figs. 19-25.

3) ULRICH (1897), Op. cit., p. 614, pl. XXXVII, figs. 34.

4) A. D'ORBIGNY (1842), Voyage dans l'Amérique Méridionale.

5) J. W. SALTER (1861), On the Fossils, from the High Andes, collected by Dr. Davis FORBES, (Quart. Jour. Geol. Soc. London, Vol. 17,) pp. 70-71, pl. V.

6) A. ULRICH (1893), Palaeozoische Versteinerungen aus Bolivien, (Neues Jahrb. f. Min. VIII Beil-Bd.) p. 87, Taf. V, figs. 22.

7) O. TORELL (1879), Petrificata Suecana Formationis Cambricae, (Lunds Univ. Ars-Skr. 6, No. 8,) pp. 6-7.

8) J. G. BORNEMANN (1887), Die Versteinerungen des Cambrischen Schichtensystems der Insel Sardinien, (Nov Acta Kais. Leop. Carol d. Akad. d. Naturf. Bd. 51,) p. 12.

9) P. H. SAMPELAYO (1933), El Cambriano en España, (Inst. Geol. y. Min. de España, Madrid.)

10) J. SAMSONOWICZ (1920), Sur la Stratigraphie du Cambrien et de l'Ordovicien dans la Partie orientale des Montagnes de Świety Krzyz (Sainte Croix), Pologne centrale, (Bull. du Serv. géol. de Pologne Vol. I, Liv. 1,) p. 18.

Cruziana semiplicata SALTER[1] is a Tremadoc species of England.

A good display of *Cruziana* is known from the Grés Armorican from Normandy and Bretagne to Portugal, in the latter of which a monograph has been written by DELGADO.[2] THORAL[3] reported recently the occurrence of *C. cordieri*, *C. goldfussi* and *C. furca* in the Lower Argenian of Montagne Noire.

In North America two species, *linnarssoni* and *rustica*, have been described from the Acadian of Arizona.[4] Although the former may be a true *Cruziana*, it is doubtful if the latter belongs to the genus. Besides, five species of *Cruziana* from the Ordovician and Silurian are now referred to *Rusophycus*, but according to BASSLER,[5] the two genera may be identical.

Subsequent to LEGENDRE and LEMOINE's announcement[6] of the occurrence of *Cruziana*, YIN[7] reported *C. monsplelliensis*, *C. prevosti*, and *C.* aff. *prevosti* from Yunnan and Scechuan. ABEL[8] reported the occurrence of *Cruziana* in the Upper Devonian sandstone of Worcester, in Kapland, South Africa. I do not, however, know of any record of the genus from the Arctic region and Australia.

This fossil, which usually occurs in arenaceous rock, is, as a rule, bilobed so that DELGADO, in 1885, called it *Bilobites*. This name, however, was already given in 1775 by LINNE to a brachiopod genus, with the result that, in 1921, KARL KREJCI-GRAF[9] introduced *Bilobichnium* for DELGADO's *Bilobites*.

Cruziana has been a problematicum. It was regarded as a plant remain or animal trail. SAPORTA suggested that it is an algal remain,

---

1) J. W. SALTER (1833), A Catalogue on the Collection of the Cambrian and Silurian Fossils etc. p. 10.

2) J. F. N. DELGADO (1886), Etude sur les Bilobites et autres Fossiles des Quartzites de la Base du Système silurique du Portugal, Lisbonne.

3) M. THORAL (1933), Découverte de nouveau Gisements fossilifères dans le Postsdamien et l'Arenig inferieur de la Montagne Noire, (C. R. Acad. Sci. Paris 196), pp. 795-797.

4) WHITE (1874), Georg and Geol. Exp. and Surv. west 100th Mer. Prelim. Rept. p. 5. (1877) U. S. Geol. Surv. west 100th Merid. 4, p. 32. pl. I, figs. 2. a-c. p. 33, pl. I, figs. 1 a-b.

5) R. S. BASSLER (1915), Bibliographic Index of American Ordovician and Silurian Fossils, (U. S. Nat. Mus. Bull. 92.)

6) A. F. LEGENDRE and P. LEMOINE (1916), Massif Sino-Thibetan Provinces du Setchouen du Yunnan et Marches Thibetaines, p. 145, p. 231, pl. XI, figs 1-2.

7) T. H. YIN (1933), On the Occurrence of (*Cruziana Bilobites*) in Yunnan and Szechuan (Bull. Geol. Soc. China, Vol. XII), pp. 75-80 pl. I.

8) O. ABEL (1935), Vorzeitliche Lebensspuren, Jena, pp. 253-256.

9) KARL KREJC-GRAF (1921), Definition der Begriffe Marken, Spuren. Fährten, Blauten, Hieroglyphen und Fucoiden, (Senckenbergiana 14, 31.)

probably resembling the Siphonee, but NATHORST took it for the trail of an invertebrate animal. The latter view now prevails more than the former. UIRICH at one time was of the opinion that it might even be a sponge, but no structure has been observed indicating the spongy nature of the fossil.

ABEL suggested that *Cruziana* is a trilobite trail, and emphasized the point that its distribution from Cambrian to Devonian agrees with the flourish of the trilobite group.

I have never seen an occurrence which is essentially important for the study of such a problematicum. But since it is said that the convex side of the *Cruziana* faces downward, it probably is an animal trail.

In connection with the sedimentation condition of *Cruziana* sandstone, I wish to call attention to the circular or subspherical depression irregularly scattered over the bilobed body and crossing the transverse oblique furrows. It can be seen on *C.* cfr. *furcifera* from Tambillos. It is not unlike the bladder of *Sargasum*, but the comparison is questioned, because no connection exists between the spherical body and the oblique furrow or ridge. The aspect of the body is certainly suggestive of the rain drop. I presume that this slab is telling us of an Ordovician episode of the shallow and quiet shore of Tambillos where a shower passed after a gigantic trilobite (?) crawled over the ground.

Cruziana cfr. *furcifera* D'ORBIGNY

Plate VIII, figures 6-7

1886. cfr. *Cruziana furcifera* DELGADO, Op. cit., p. 34, pl. I-VII, XI, fig. 1, pls. XVIII, fig. 2, pl. XXI, figs. 3-4, pl. XXVI, fig. 2. (Old references cited.)
1893. cfr. *Cruziana furcifera* ULRICH, Op. cit., p. 86.
1912. *Cruziana* cfr. *furcifera* HOEK, Op. cit., p. 241, pl. IX, fig. 4.

It is a great drawback in this identification that I could not gain access to D'ORBIGNY's original description. DELGADO, however, gave a precise description, besides numerous illustrations of the species. The three specimens in hand agree with his *furcifera* in most details, except for the circular spots or depression scattered on the surface. Therefore, I hesitate to make any specific identification.

Formation and locality:—*Cruziana* sandstone; Tambillos, upper course of Pilcomayo, Bolivia.

Cruziana sp.

Plate VIII, figure 5

1912. *Cruziana* cfr. *furcifera* HOEK, Op. cit., p. 193.

This form differs from the preceding in the smaller size, much shallower concavity, absence of circular spots or depressions. Further, oblique furrows or ridges are disconnected regularly at a certain distance apart, in which respect it appears to be different generally from *Cruziana*, so far as I have examined the literature on the subject.

Formation and locality:—*Cruziana* sandstone; Palca del Tunari, Cochabamba, Bolivia.

Postscript

It was in the summer of 1929, that Professer G. STEINMANN visited Japan on his way back from the Fourth Pan-Pacific Scientific Congress at Java. At that time I was a graduate student at the Tokyo Imperial University, and was deputed by Professor H. YABE and ProfessorT. KATO to act as guide to Professor STEINMANN. This gave me an opportunity to join him in his trips, one of which was to the Island of Shikoku. This trip included the Sakawa basin, where I had already discovered a "Decken-structure" of some magnitude. There he gave me valuable informations in connection with my tectonic research of the area. At that time I hoped, and expected some day, to go to Bonn, but never did I even dream that I should later be studying his valuable Cambro-Ordovician collection of South America. As a matter of fact more than half the present material is from his collection. On laying down my pen, my heart is full, with deep regrets that he cannot see the fruition of my studies.

December 20th, 1936.

After completing this manuscript, I read Dr. H. J. HARRINGTON's paper, "On some Ordovician Fossils from Northern Argentina" (Geol. Mag. Vol. 74, 1937, pp. 97-128, pls. 5-7). This study deals with Prof. KEIDEL's collections from Quebrada del Toro, Province Salta and Quebrada de Chalala, near Quebrada de Purmamarca, Province Jujuy, KEIDEL determined the stratigraphic succession in the pre-Puna region as below:—

Ordovician	Incamayo group	Unfossiliferous beds with indeterminable inarticulate brachiopods
	Parcha group	Upper beds, unfossiliferous
		Basilicoides zone
	Saladillo group	Fossiliferous beds of the marine glacial deposits
	Disconformity	
	Cardonal group	*Leiostegium* zone
		Kainella zone
		Quartzitic sandstones, etc.
		Slaty sandstones, etc.
Cambrian		Upper quartzitic sandstones
		"*Scolithus*" sandstones
		Lower quartzitic sandstones
Unconformity		
Proterozoic beds with granitic intrusions, folded during pre-Cambrian times		

HARRINGTON notes that the *Kainella* fauna, exclusive of *Oxydiscus keideli* of Parairie Catamarca, which I described during my stay at the U. S. National Museum, was in fact collected by Keidel from Quebrada Colorada, near Iruya, in Province Salta. According to KEIDEL's opinion, *Eoorthis* ("*Orthis*") *saltensis* described by HOEK from Aguas Calientes (Quebrada Reyes) corresponds to the *Leiostegium* zone, and *Conocephalites* cfr. *striatus* sandstone and *Crepicephalus* ("*Olenus*") *argentinus* sandstone reported by KAYSER to the *Scolithus* sandstone.

HARRINGTON described the following fossils from the 5 zones:

1) *Kainella* zone of the Cardonal group at Quebrada del Toro.
Lingulella á sp. indet.
Eoorthis (?) *putilliformis* KOBAYASHI

Andesaspis argentinensis KOBAYASHI
Kainella conica KOBAYASHI

2) *Leiostegium* zone of the Cardoñal group at Quebrada del Toro.
Obolus (?) *lampazarensis* HARRINGTON
Lingulella b. sp.
Lingulella (?) c sp.
Eoorthis saltensis (KAYSER) WALCOTT
Hyolithus sp. indet.
Keidelaspis saltensis HARRINGTON
Leiostegium douglasi HARRINGTON

3) Arenaceous-calcareous beds of the Saladillo group at Quebrada del Toro.
Eoorthis bifurcata HARRINGTON
Oxydiscus keideli KOBAYASHI
Gastropoda, gen. et sp. indet.
Endoceras a sp.
Endoceras b sp.

4) *Basilicoides* of the Parcha group at Quebrada del Toro
Endoceras c sp.
Basilicoides taurinus HARRINGTON

5) *Asaphellus* zone of Quebrada de Chalala.
Cystoidea, gen. et sp. indet.
Obolus (*Broggeria*) cfr. *salteri* (HOLL) WALCOTT
Eoorthis saltensis (KAYSER) WALCOTT
Eoorthis christianiae (KJERULF) WALCOTT
Hyolithus (*Orthotheca*) *multistriatus* HARRINGTON
Agnostus sp. indet.
Asaphellus jujuanus HARRINGTON
Protopriomerops primigenus (ANGELIN) KOBAYASHI

He states that the *Asaphellus* fauna indicates the Atlantic facies of the Basal Ordovician, and *Kainella* and *Leiostegium* faunas the Pacific facies of the Late Ozarkian. The stratigraphic relation of the two facies, however, is indeterminable. As described already on page 397, I have studied several slabs in STEINNMAN's collection on which *Kainella* and *Asaphellus* are found associated. During my visit to Freiburg i. Br. I saw also a slab of *Kainella* shale with *Dictyonema*. Furthermore, since in BROWN's collection, *Asaphellus* is accompanied with *Leiostegium*, the late Ozarkian can safely be equated to the

Tremadocian, as stated elsewhere. The *Basilicoides* zone is considered to be Llandeilian because of the morphic affinity of *Basilicoides* to *Basilicus* and *Ogygitoides.* The Saladillo fauna, which is located beneath the *Bosilicoides* zone, is supposed to be the late Beekmantown.

Keidelaspis and *Basilicoides* are new genera, based on *Keidelaspis saltensis* and *Basilicoides taurinus* respectievely. The former genus can be distinguished from *Andesaspis* by its longer frontal limb and entire pygidium. The latter genus differs from *Basilicus, Parabasilicus,* and *Basiliella* by its isoteliform facial suture and from *Pseudobasilicus, Ogygitoides, Pseudogygites,* and *Ogygites* by its multisegmented parabolic pygidium. *Basilicoides* is regarded as an intermediate form between *Basilicus* and *Ogygitoides*

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Photo. by Ueki.

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Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. II, Vol. IV, Pt. 4, Pl. II.

Photo. by Ueki.

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[illegible] Shelly Faunas of South America.

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Photo. by Ueki.

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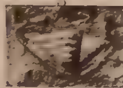
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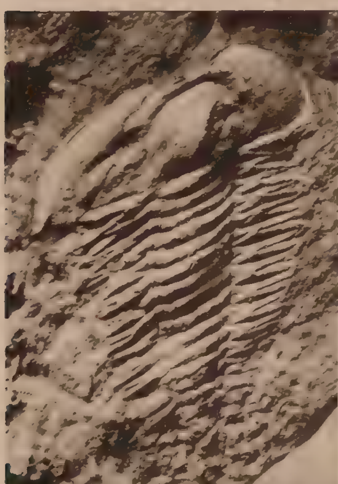
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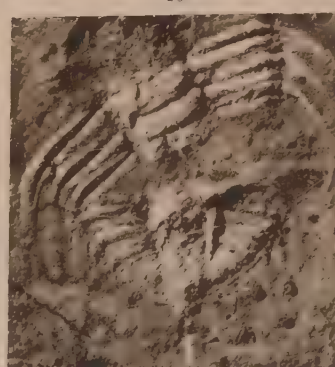
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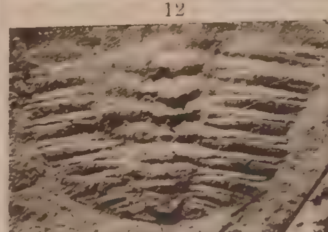
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Photo. by Ueki.

T. Kobayashi:

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Plate V

Cambro-Ordovician Faunas
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Figure 10. Cephalon and thorax; $\times\frac{2}{3}$

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Parabasilicus aff. *typicalis* KOBAYASHI . . . . p. 503

Figure 11. Pygidium; ×1

Middle Ordovician sandstone in the upper course of the Pilcomayo, Bolivia.

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Cambro-Ordovician Faunas
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Plate VII

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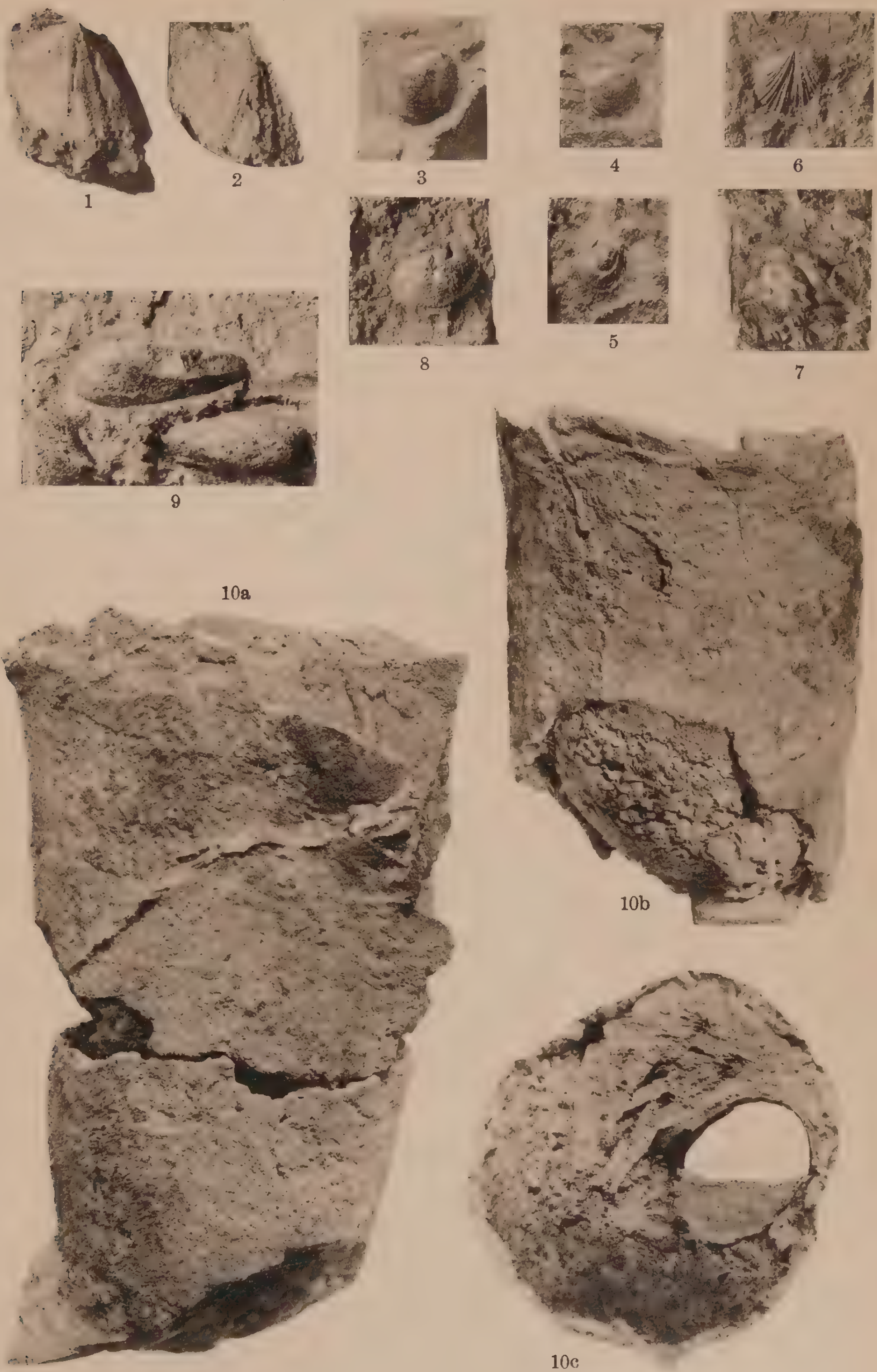

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